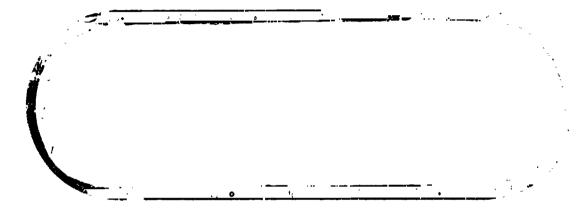
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NASA-CR-124415) EVALUATION OF

MSFC-STD-486, ''THREADED FASTENERS,

TORQUE LIMITS FOF'' FOR USE IN CHE

CONSTRUCTION OF (Boeing Co., Seattle,

Wash.) 291 p HC \$15.75 CSCL 225 G3/31 15643



THE BOEING COMPANY SOUTHEAST DIVISION LAUNCH VEHICLE BRANCH

T5-6785-5

DOCUMENT NO. _

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Limits	For" For Use	In The Const	ruction Of	Aerospace V	ehicles	
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ABSTRACT

MSFC-STD-486, "Threaded Fasteners, Torque Limits For." is a relatively new standard that has not had much user experience. This test was run to provide such experience and verify the values in MSFC-STD-486. This was accomplished by plotting torque-tension curves on aluminum and alloy steel aircraft quality bolts and nuts through 1/2 inch in diameter.

KEY WORDS

BOLT

NUT

TORQUE

TENSION

MSFC-STD-486

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APPENDIX

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1.0 OBJECT

The object of this test was to verify MSFC-STD-486, "Threaded Fasteners, Torque Limits For," dated September 30, 1968, including Ammendment I dated July 14, 1970 as an acceptable specification for the installation of threaded fasteners, through 1/2 inch diameter, in spacecraft.

2.0 BACKGROUND

MSFC-STD-468, "Threaded Fasteners, Torque Limits For," dated September 30, 1968, is a relatively new specification and has not been used sufficiently to garner much information as to its usefulness. This test was conducted to determine such usefulness.

3.0 <u>CONCLUSIONS AND RECOMMENDATIONS</u>

MSFC-STD-486, "Threaded Fasteners, Torque Limits For," dated September 30, 1968, has been found to be unsatisfactory for installing aircraft quality fasteners. The reasons for this conclusion are:

- 1. The specified torque values can produce excessive stress in the bolt.
- 2. The specification requires that locking torque of self-locking fasteners be added to the tabulated values. This makes inspection of the installed fastener assembly impractical. Whereas if the tabulated values included compensation for locking torque an inspector could check the assembly by attempting to tighten it at the indicated value.
- 3. It contains no values for high strength corrosion resistant steel (CRES) or titanium fasteners which are used extensively in aerospace vehicles.
- 4. The lubrication notes are confusing. Most nut specifications allow the nuts to be supplied lubricated by the nut manufacturer. Other requirements of these specifications, such as locking torque and reusability, make it more attractive for a manufacturer to supply lubricated nuts than unlubricated nuts. Therefore most nuts are supplied lubricated when permitted by the specification. The as supplied nuts must meet the same performance requirements whether they are lubricated or not. Hence nuts should be used in the as received condition.

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3.0 CONCLUSIONS AND RECOMMENDATIONS (Continued)

- 4. The addition of a fresh lubricant can provide more consistent torque versus tension results, and is necessary when using some nut-bolt material combinations. However, the mechanic installing the fastener can not be relied on to determine which parts have been lubricated by the manufacturer. If an in-house lubricant is required it should be an engineering responsibility and the lubricant, method of application, and appropriate torque should be controlled by the engineering drawing.
- 5. The torque wrench specification (GGG-W-686) referenced precludes the use of automatic tools, many of which are suitable for aerospace fastener installation.
- 6. No differentiation is made for tightening the assembly by turning either the bolt or the nut.

This test did not attempt to test a significant sample of fasteners to the requirements of MSFC-STD-486. The results obtained from test parts should not be considered representative of the entire class. These parts tested were usually from one lot, by one manufacturer. (The parts used were obtained for this test and were comprised chiefly of surplused items from the S-IC program. As such, no records were available on the history of these parts.)

Items known to affect the torque-tension relationship in threaded connections included:

Fastener Geometry Surface Finish, including bearing surfaces of the material being fastened Strength and hardness of the materials involved Lubrication; method of application, and shelf life Locking torque of self-locking fasteners Twisting the nut Twisting the bolt head, and hole size

The inter-relationship of these variables is not known, nor was it investigated in this test. This test attempted to duplicate conditions that would occur if MSFC-STD-486 was used for production installation of aerospace fasteners. The most significant result of this test is the excessive stress produced by the specified torque under the test conditions. Whether this load is detrimental to the fastener assembly is dependent upon many factors. Among which are:

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3.0 <u>CONCLUSIONS AND RECOMMENDATIONS</u> (Continued)

- 1. Materials involved
- 2. Environmental conditions of the assembly
- 3. Design load, i.e. tension, shear, fatigue, or combined loading
- 4. Anticipated service life
- 5. Fastener geometry
- 6. Safety factor

It should be noted, however, that the failure mode on bolted connections during installation is usually thread stripping. This is a readily inspectable defect which is usually repaired immediately. Parts that do not fail on installation but which may have been subjected to excessive torque should be individually evaluated.

4.0 PROCEDURES AND RESULTS

The test fixture electronics consisted of a hollow load cell, a torque transducer, an amplifier and an X-Y plotter. A mechanical setup was constructed to manually apply torque to the fastener while isolating the torque transducer from side loads, and isolating the load cell from torque loads. This was accomplished by using the setup depicted on page 4. This shows a shaft rigidly supported and used to transmit torque to the test fastener. The fastener is installed in a hollow load cell which in turn is isolated from torque by angle blocks. A photograph of the entire setup is on page 5.

Due to this test setup and limitations of available equipment it was not practical to selectively tighten the assembly by turning either the bolt head or nut, or to restrain the load cell. Consequently this test did not differentiate between turning the head of a fastener or the nut during installation of the assembly: rather the element with the least friction rotated (usually this was the nut).

The following parts were tested:

3/16" Diameter (.190")

62 ksi aluminum AN3DD bolts with NAS1021D3 aluminum self-locking nuts.

125 kmi alloy steel AN3 bolts with MS21042-3 alloy steel self-locking nutm.

160 kmi alloy stool NAS1303 bolts with MS21042-3 alloy steel solf-locking nuts.

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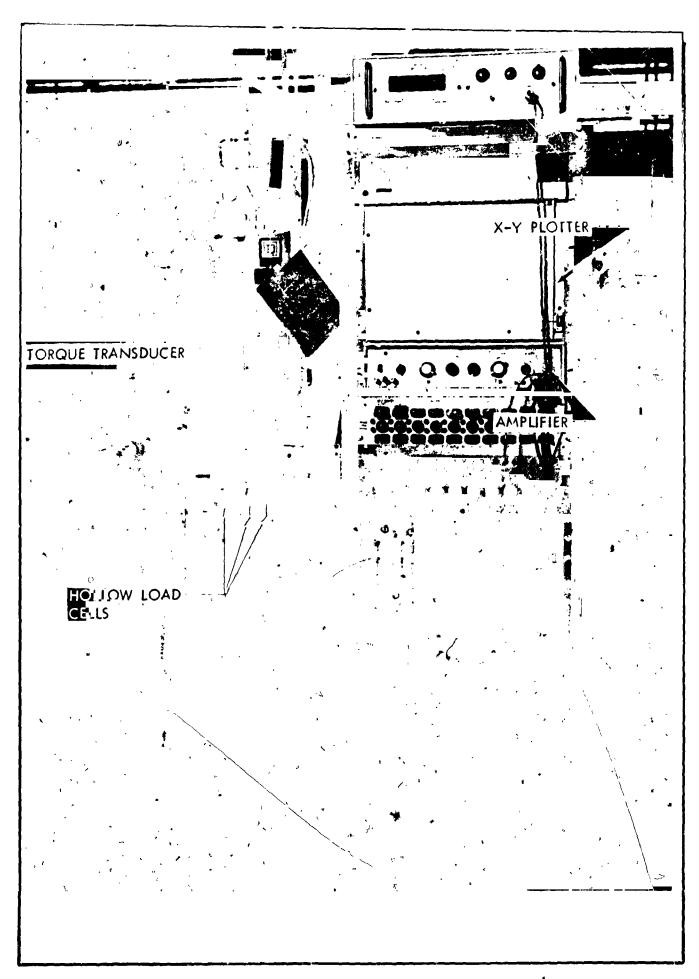
SOCKE ANGLE BLOCK BASE-SOCKET LOAD CELL CONTAINING-FASTENER ANGLE BLOCK -TORQUE TRANSDUCER

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SECTION PAGE 5

4.0 PROCEDURES AND RESULTS (Continued)

1/4" Diameter (.250")

62 ksi - AN4DD aluminum bolts with NAS1021D4 aluminum self-locking nuts.

125 ksi - AN4 alloy steel bolts with MS2i-A2-4 alloy steel self-locking nuts.

160 ksi NAS1304 alloy steel i lits with MS21042-4 alloy steel self-locking nuts.

180 ksi MS21250-04 alloy steel bolts with BACN10BL4L alloy steel self-locking nuts.

5/16" Diameter (.312")

62 ksi AN5DD aluminum bolts with NAS1021D5 aluminum self-locking nuts.

125 ksi AN5 alloy steel bolts with MS21042-5 alloy steel self-locking nuts.

160 ksi NAS1305 alloy steel bolts with MS21042-5 alloy steel self-locking nuts.

180 ksi MS21250-05 alloy steel bolts with BACN10BL5L alloy steel self-locking nuts.

3/8" Diameter (.375")

62 ksi AN6DD aluminum bolts with NAS1021D6 aluminum self-locking nuts.

125 ksi Δ N6 alloy steel bolts with MS21042-6 alloy steel self-locking nuts.

160 ksi NAS1306 alloy steel bolts with MS21042-6 alloy steel self-locking nucs.

180 ksi MS21250-06 alloy steel bolts with BACN10BL6L alloy steel self-locking nuts.

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4.0 PROCEDURES AND RESULTS (Continued)

7/16" Diameter (.437")

 $62\ ksi\ AN7DD\ aluminum\ bolts\ with\ NAS1021D7\ aluminum\ self-locking\ nuts$.

125 ksi AN7 alloy steel bolts with BACN10BL7L alloy steel self-locking nuts.

160 ksi NAS1307 alloy steel bolts with BACN10BL7L alloy steel self-locking nuts.

180 ksi MS21250-07 alloy steel bolts with BACN10BL7L alloy steel self-locking nuts.

1/2" Diameter (.500")

62 ksi AN8DD aluminum bolts with NAS1021D8 aluminum self-locking nuts.

125 ksi AN8 alloy steel bolts with BACN10BL8L alloy steel self-locking nuts.

160 ksi NAS1308 alloy steel olts with BACN10BL8L alloy steel self-locking nuts.

180 ksi MS21250-08 alloy steel bolts with BACN10BL8L alloy steel self-locking nuts.

Five of each of these combinations of bolts and nuts were tested in the as received condition (in all cases the as received nuts has been lubricated by the manufacturer). Five (5) more were vapor degreased (to remove the manufacturer's lubricant), lubricated with Carbowax 400, (a proprietary mixture of polyethylene glycols and methoxypolyethylene glycols, that meets the lubricant requirements of MIL-N-25027 and MSFC-STD-486) and tested. The alloy steel nuts were received with a solid film lubricant which did not dissolve in the vapor degreasing operation. However, these were tested in the same manner as the aluminum nuts, five as received and five vapor degreased and lubricated. All nuts were tested in the as received condition and with a Carbowax lubricant as the person installing these parts in a production assembly may not be able to tell if a nut has been lubricated or not. None of the bolts were received with any lubricant on them.

SECTION PAGE 7

4.0 PROCEDURES AND RESULTS (Continued)

In all cases the difference between as received parts and parts that had been vapor degreased and lubricated with Carbowax was significant. In most cases the torque values of MSFC-SPEC-486 were beyond the minimum yield strength of the bolt and in some of the tests the bolt threads stripped. On the 125 ksi steel bolts this happened several times below the minimum ultimate tensile strength of the bolt. This is believed to have occurred due to a combination of tensile load and changes in the bolt thread lead angle caused by the tensile load. This result has been observed by others and documented by a paper entitled "Calibration of Allov Steel Bolts" by R. J. Christopher, G. L. Kulak, and J. W. Fisher, Journal of the Structural Division, ASCE, Vol. 92, No. ST2, Procedure Paper 4768, April 1966.

Results are summarized in Figure I through XLVI. These figures were drawn from the most significant areas of the data sheets. The torque tension curve is shown as a straight line as it would be idealy. The line becomes dashed beyond the minimum tension yield of the bolt material and stops at the minimum ultimate tensile strength of the bolt material. The range of MSFC-STD-486 torque values are shown on these figures by shaded areas. This range of values is conservative in that the additive locking torque values are the ones plotted, rather than the measured values, which were usually higher. The range of MSFC-STD-486 torque values shown for the as received parts are taken from the tables for unlubricated parts although no "unlubricated" (lubricant removed with solvents) nuts were tested; the parts in the as received condition were unlubricated by the user.

The data sheets in the appendix are the actual plots of each fastener assembly as plotted during cesting by an X-Y plotter. The curve to the right of zero on the abscissa (torque) was generated during installation; the curve to the left during removal.

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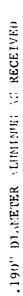
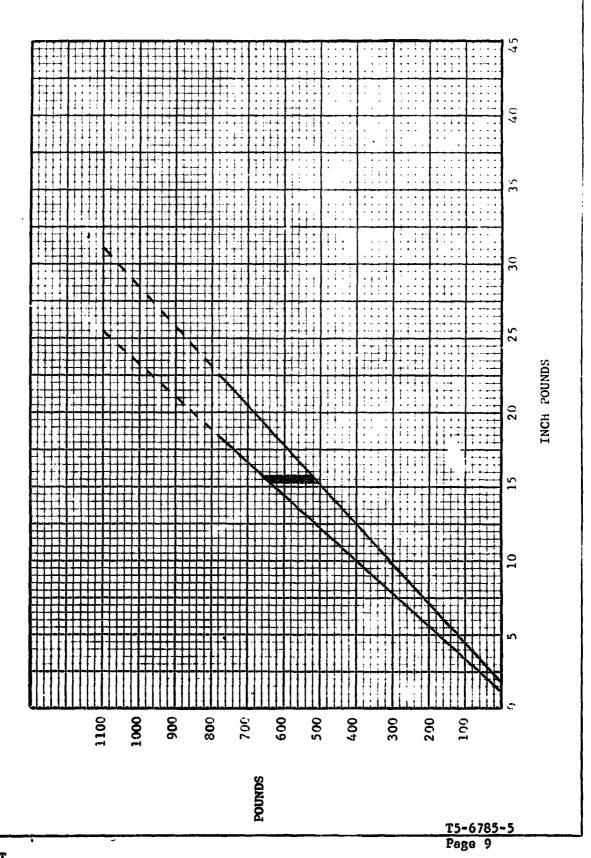
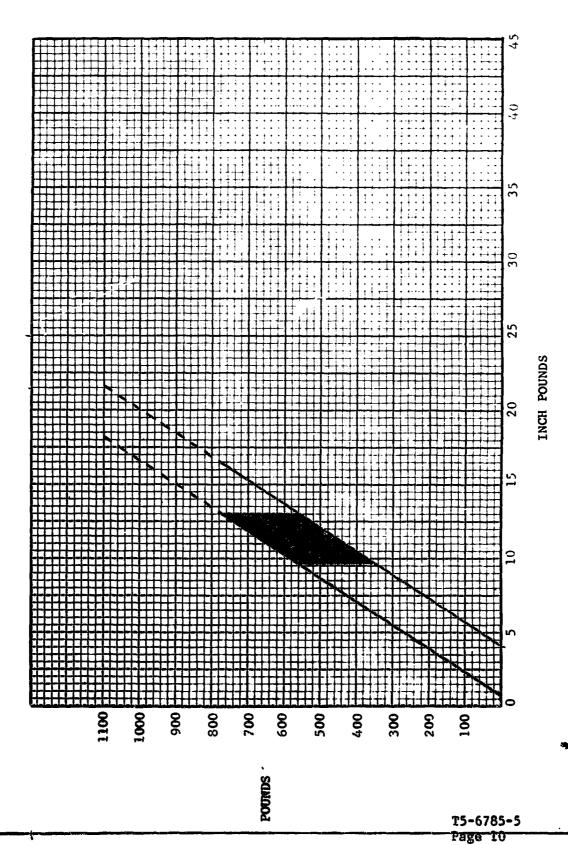




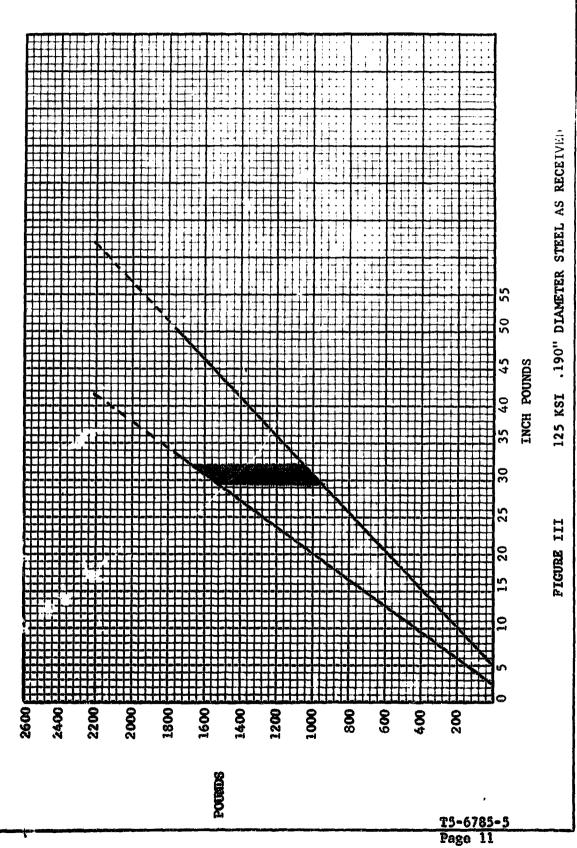
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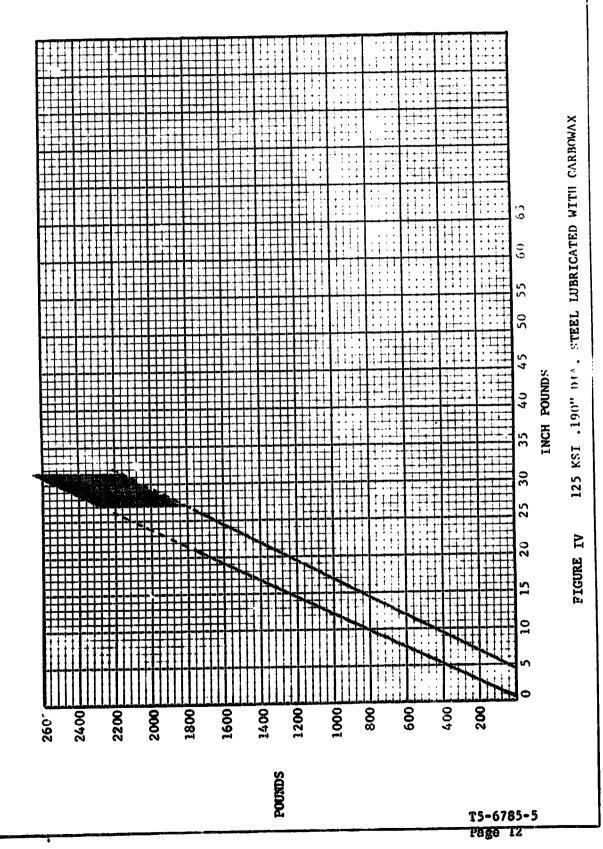




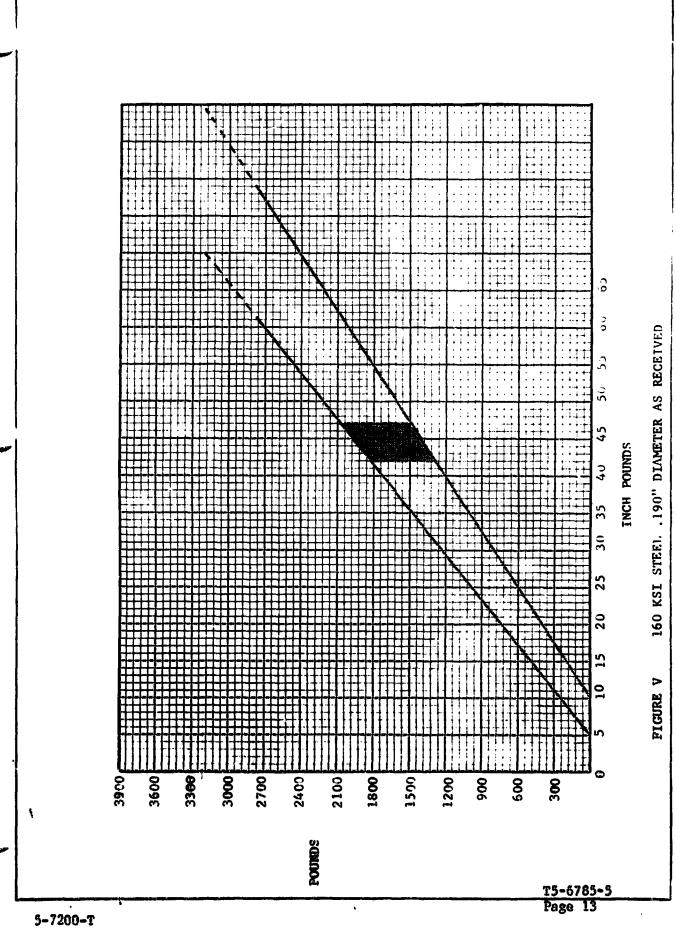
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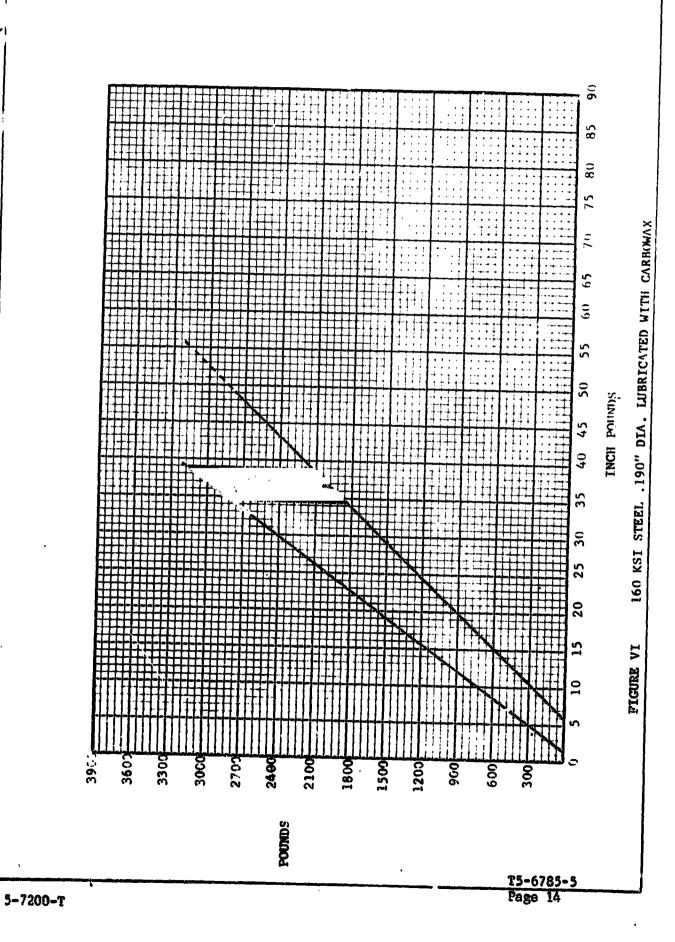
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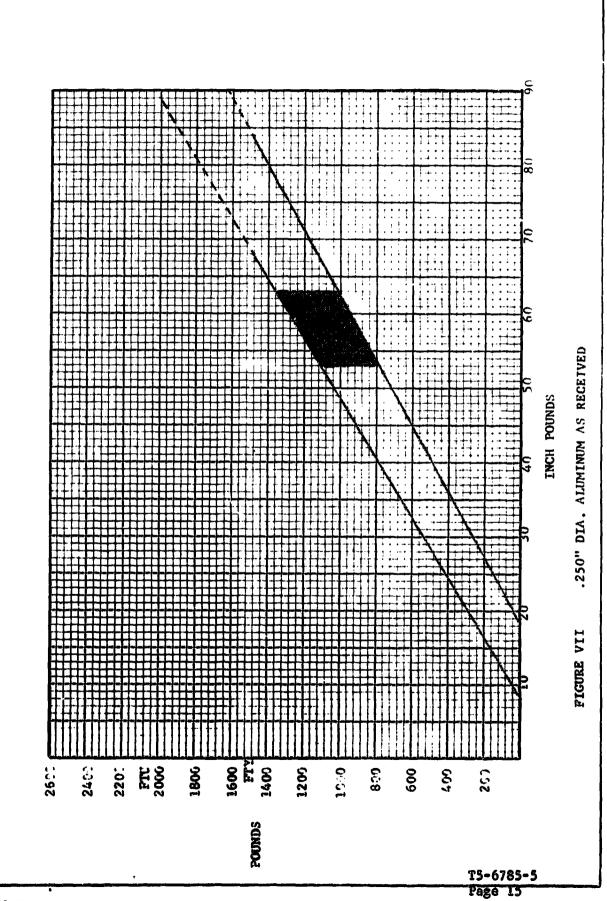


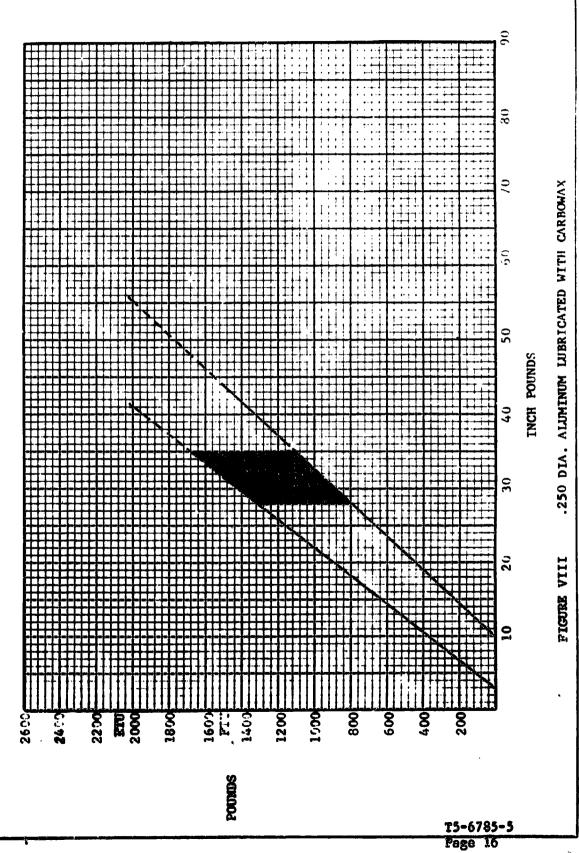


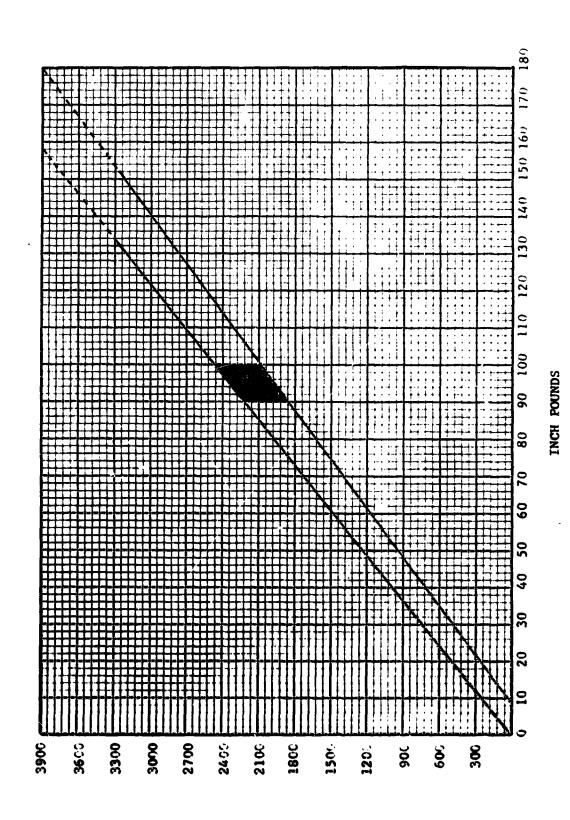
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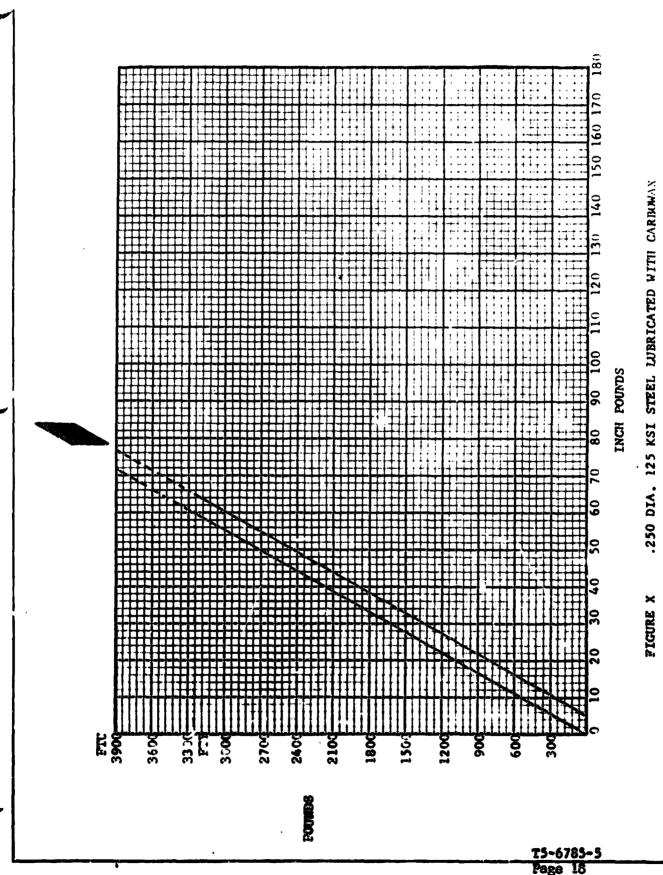


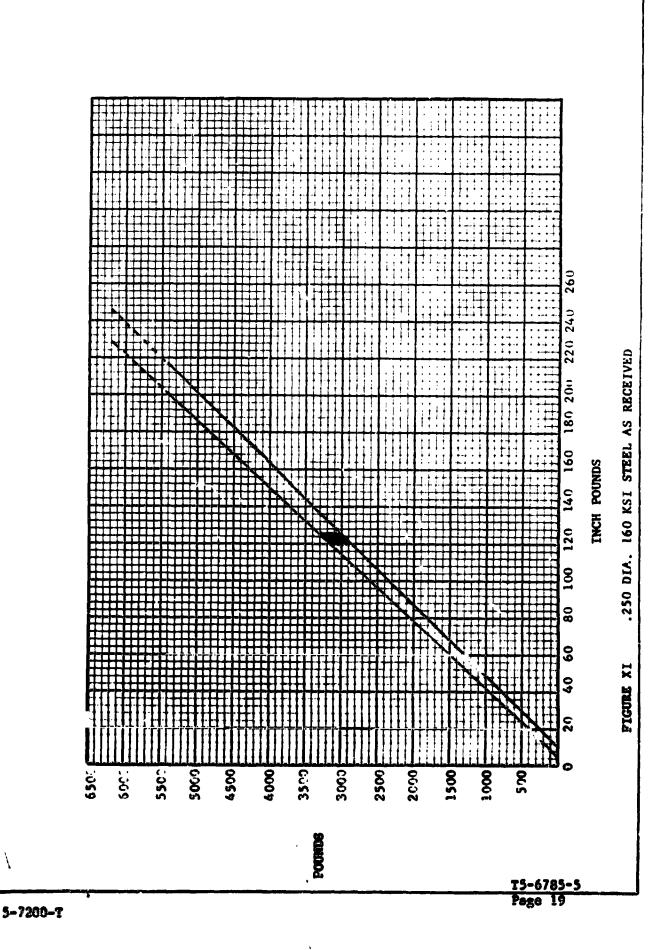




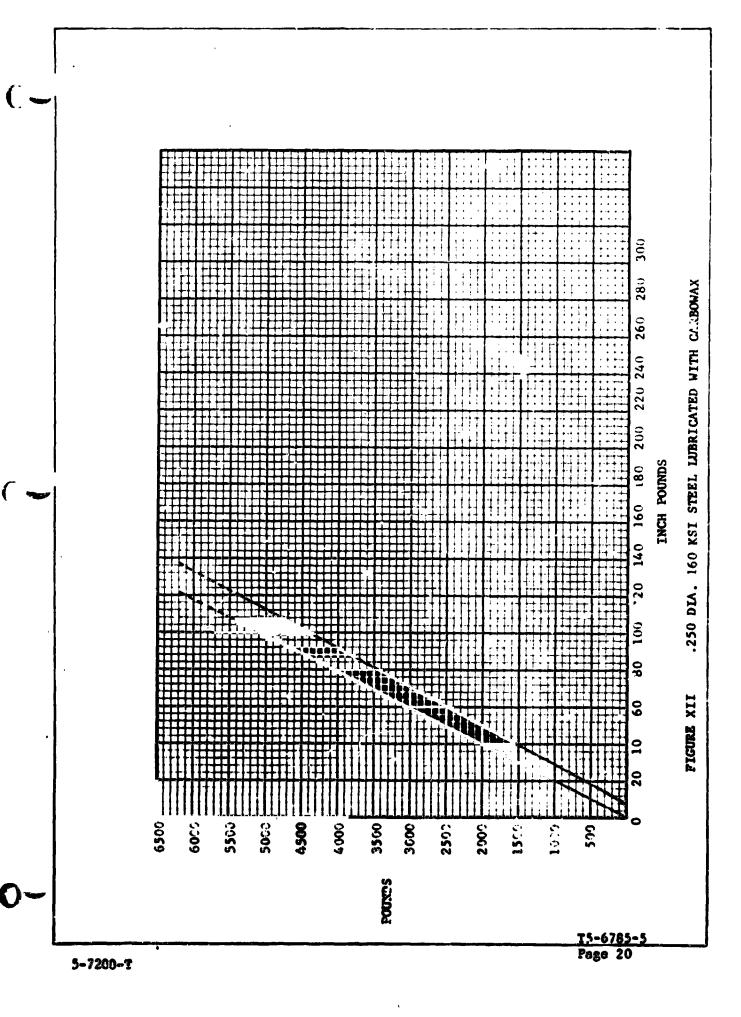


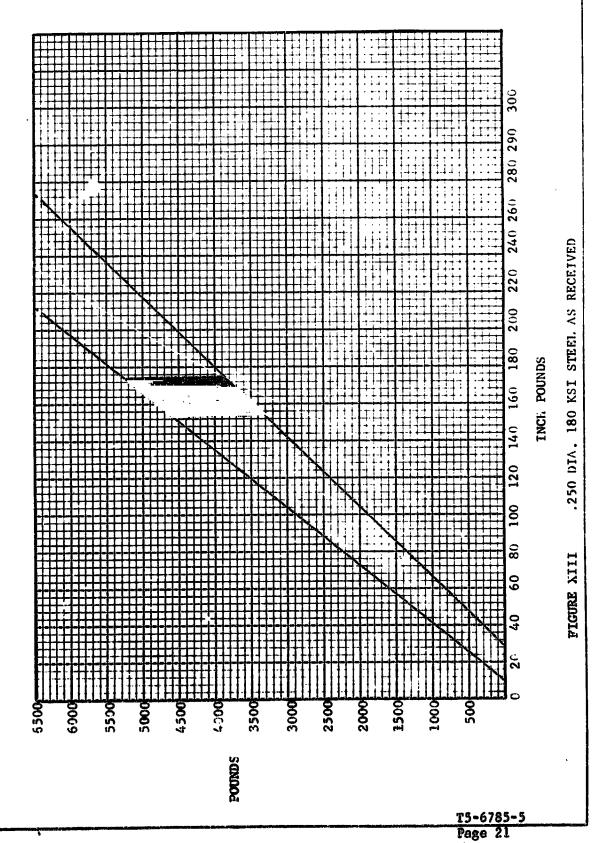
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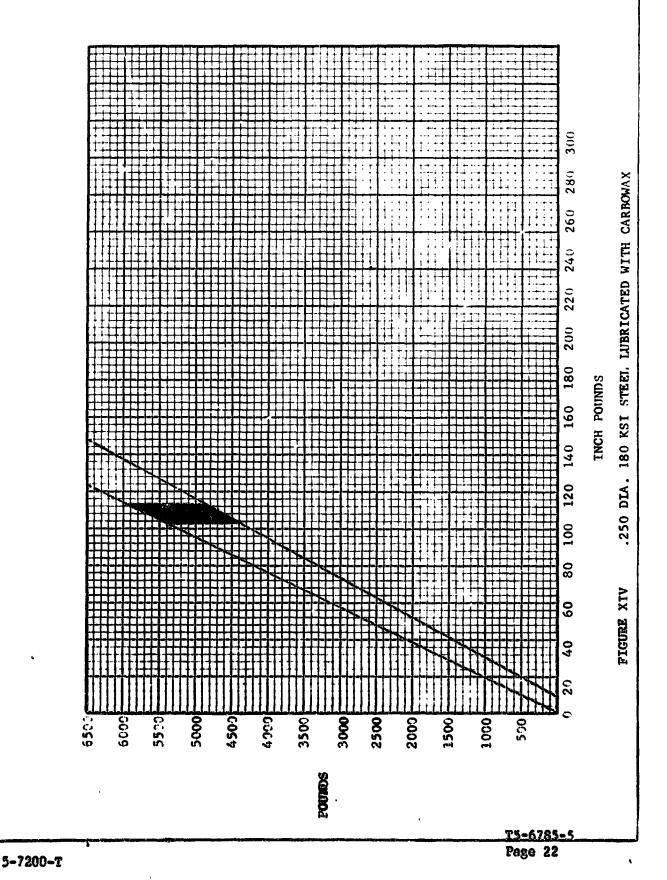


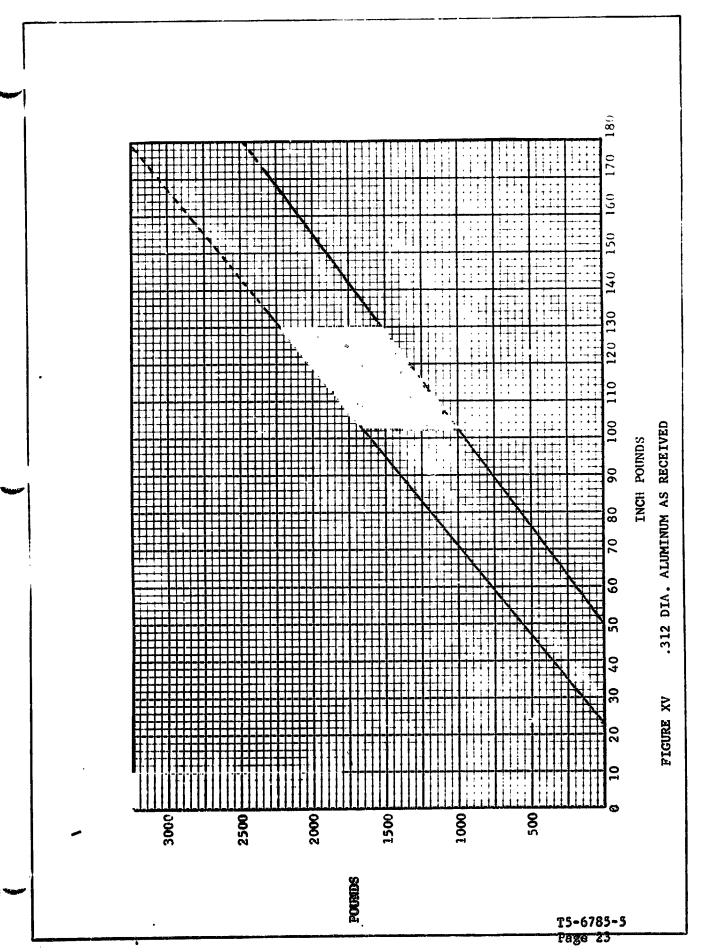


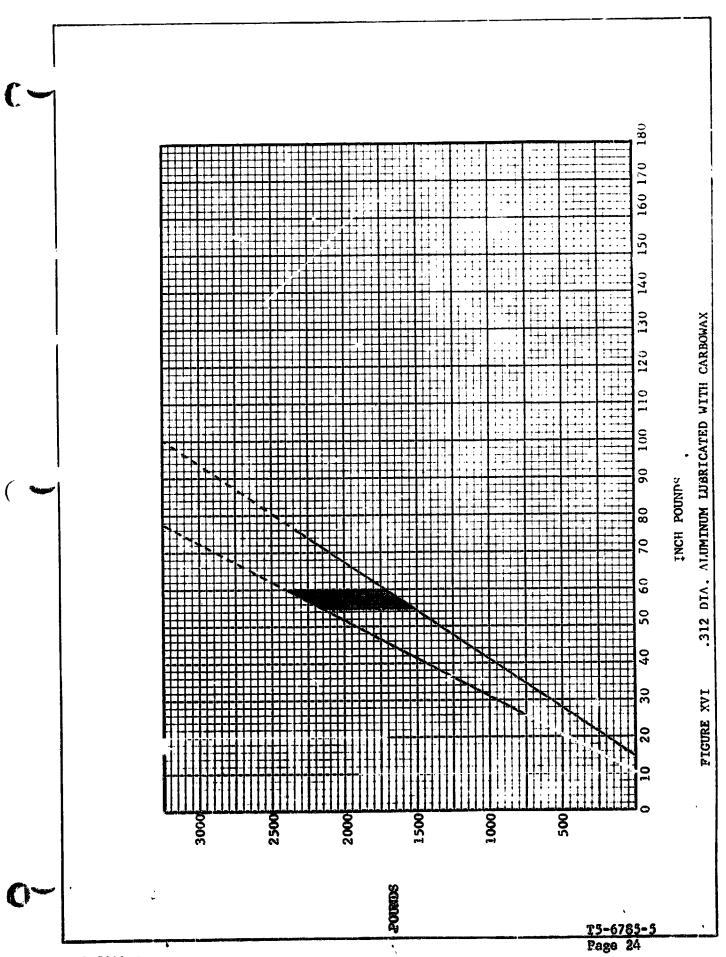
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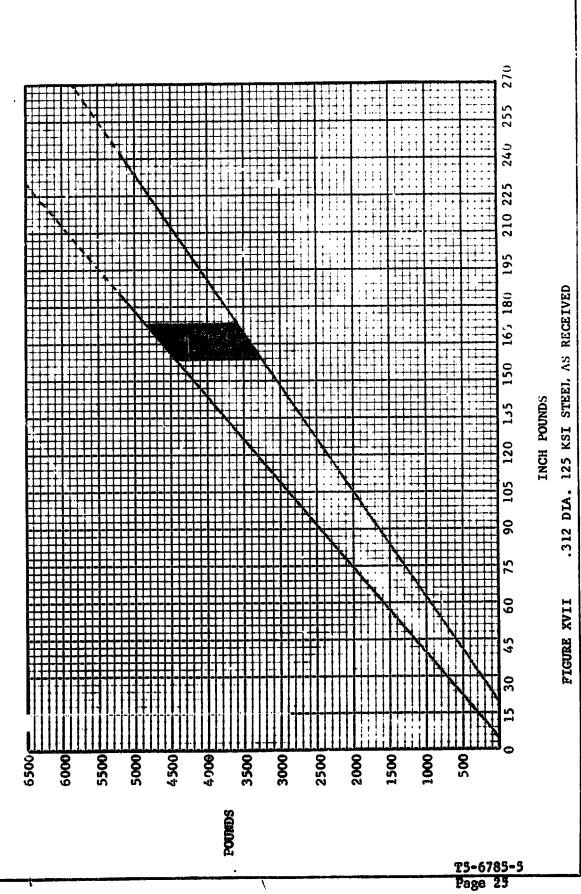




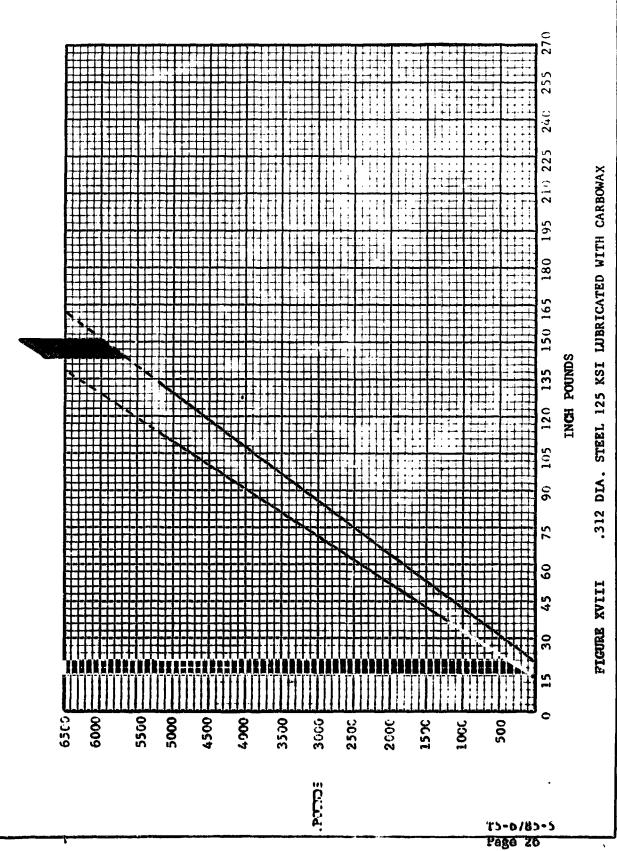


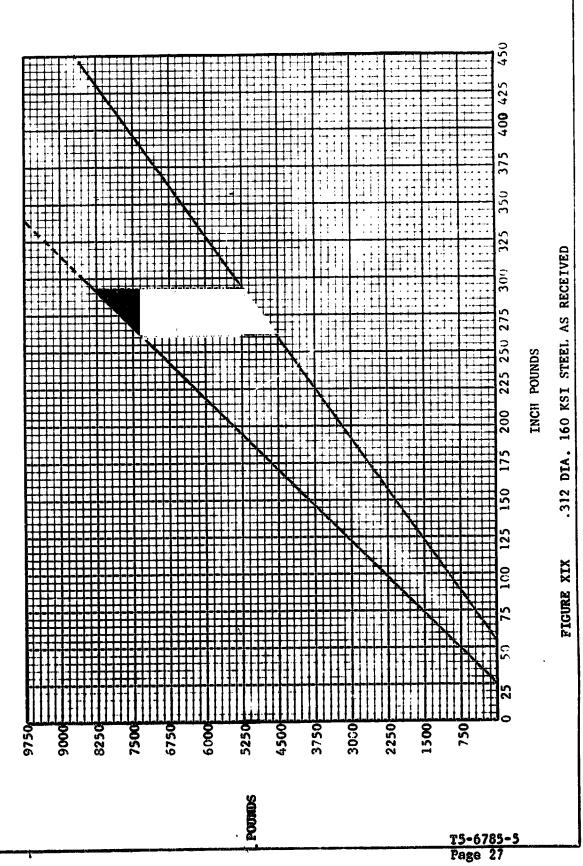


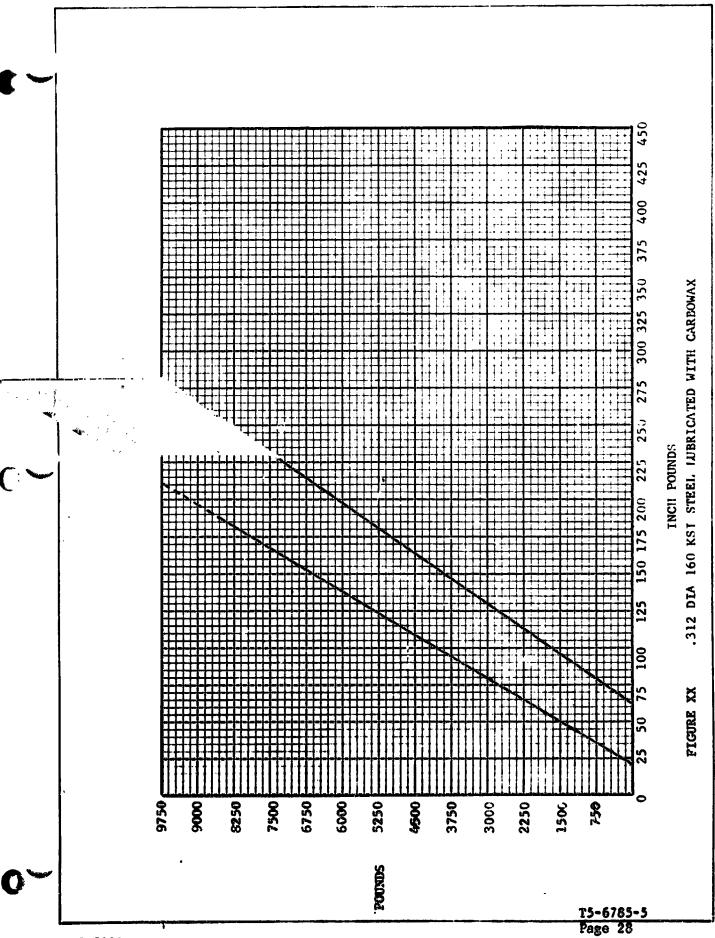


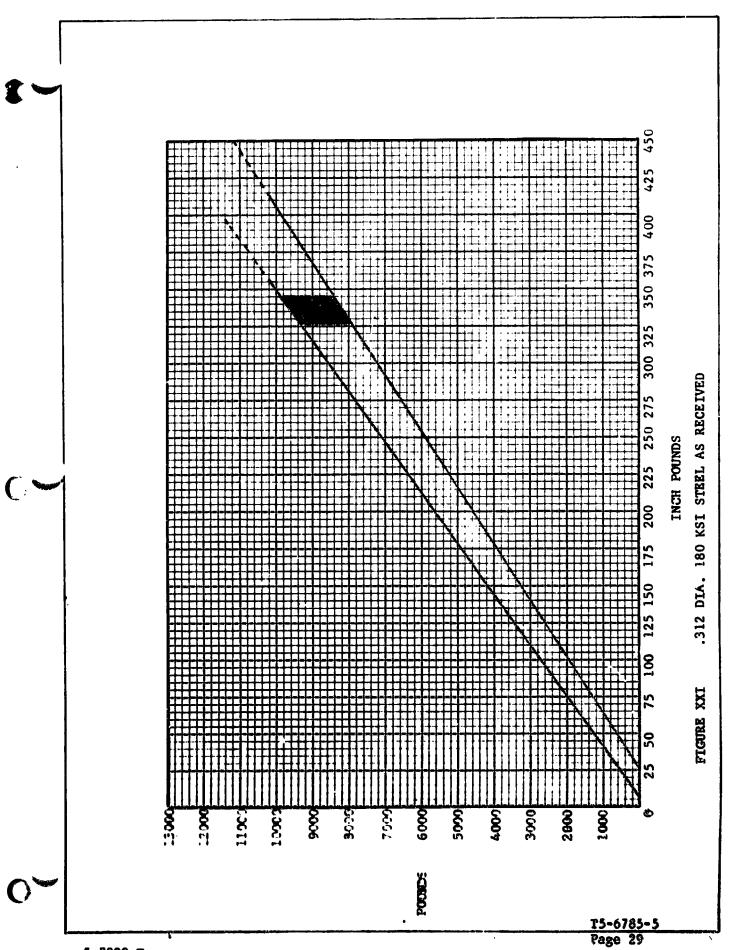


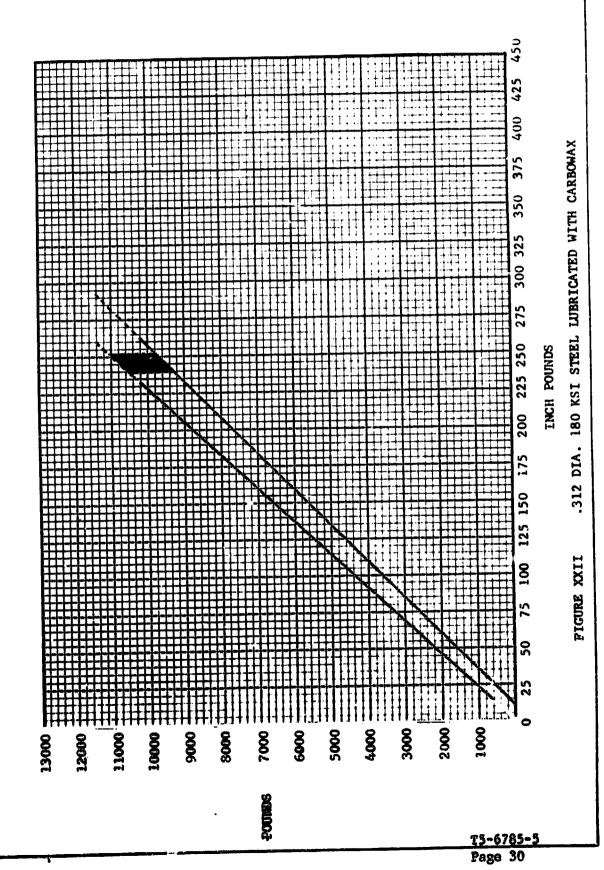
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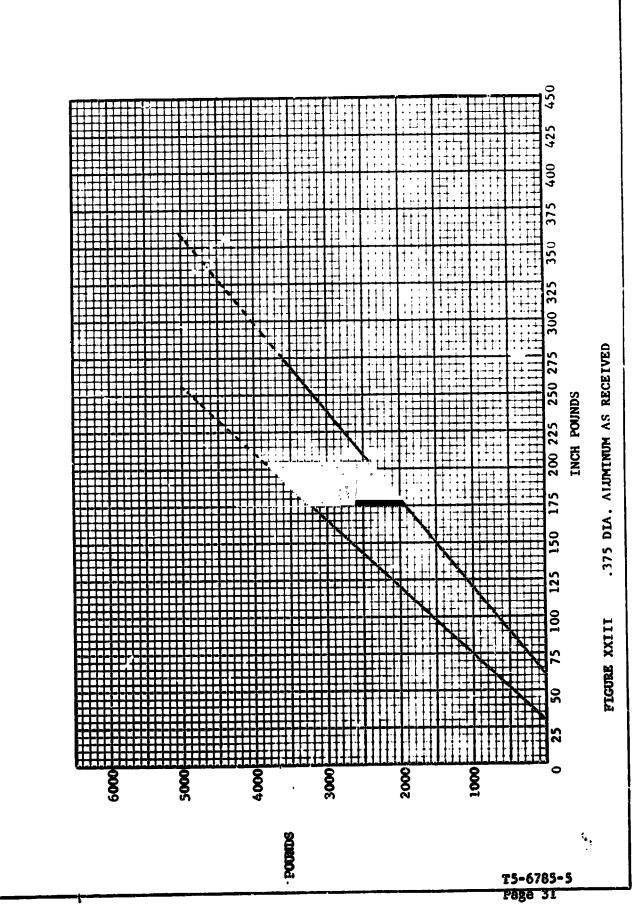


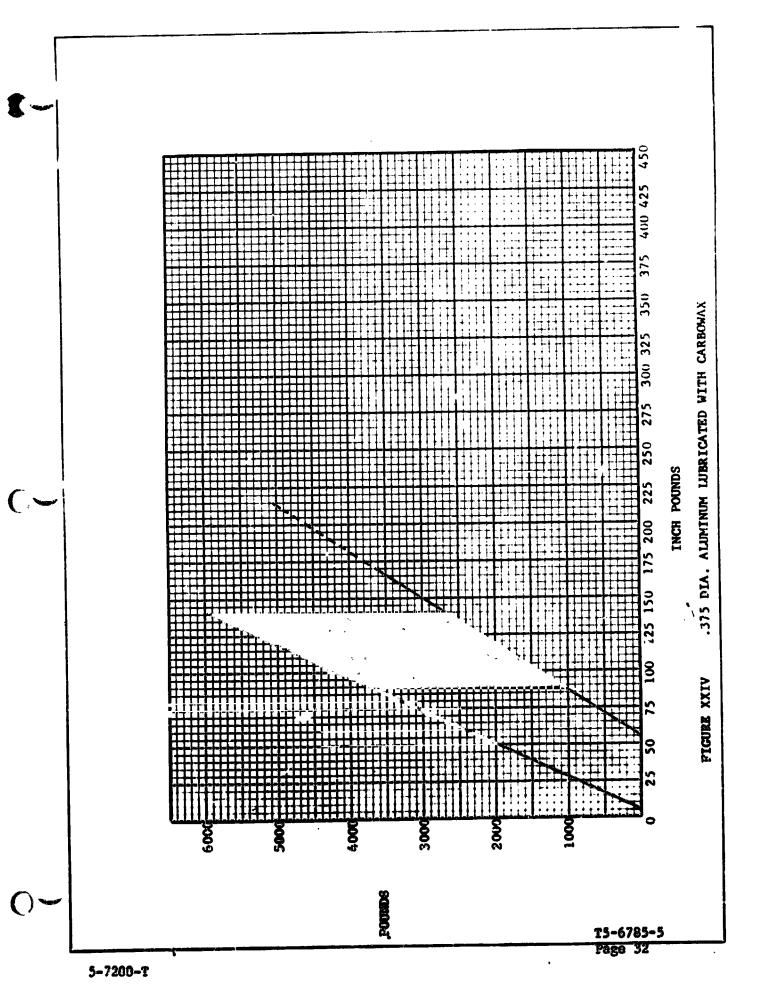


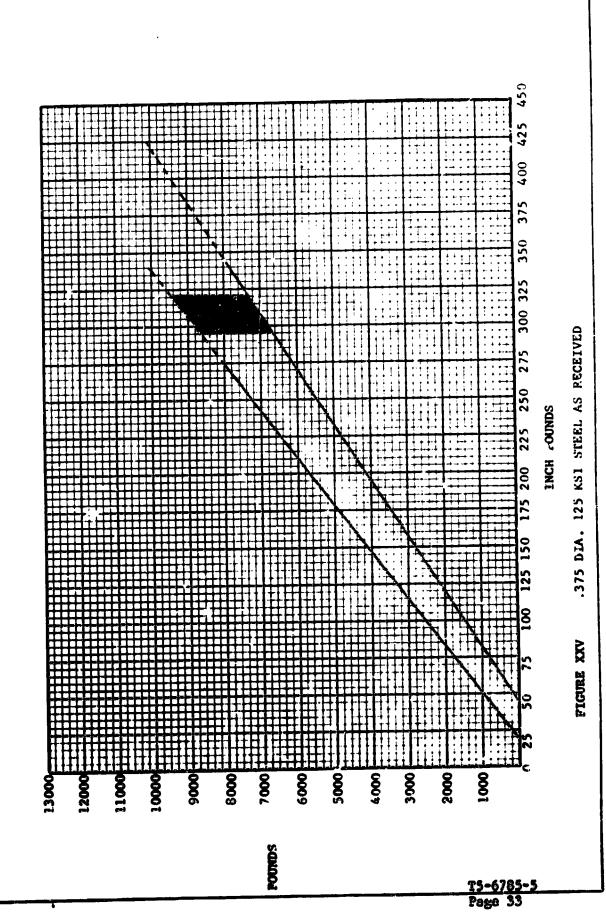


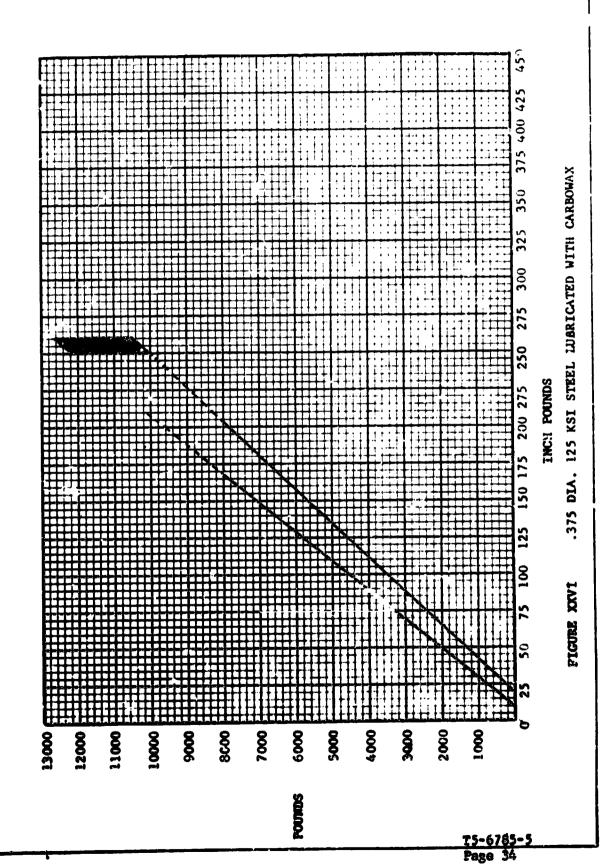


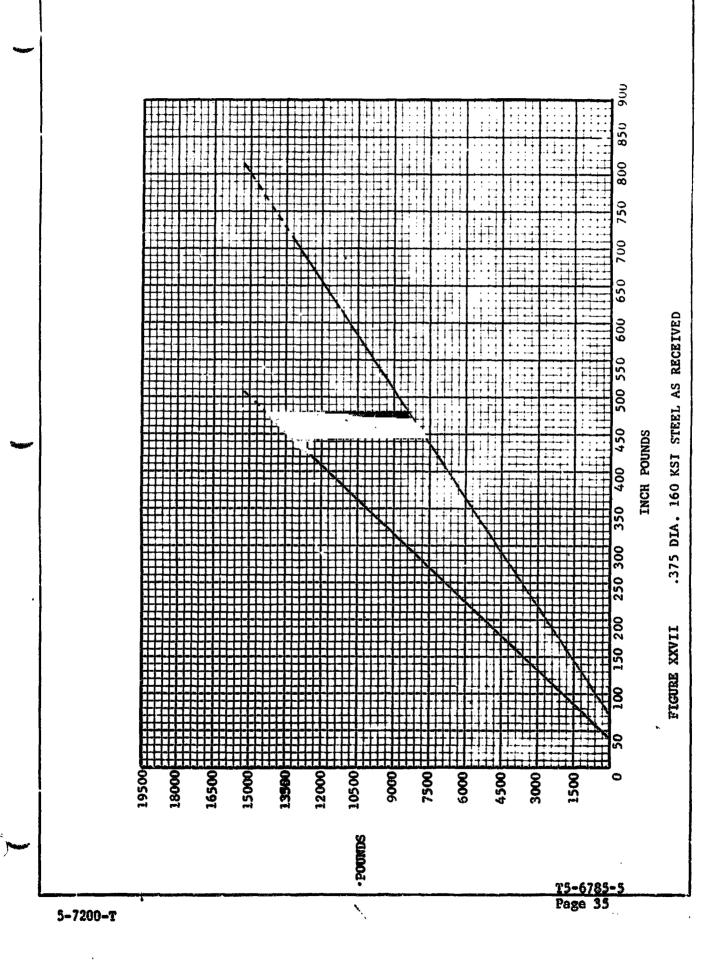


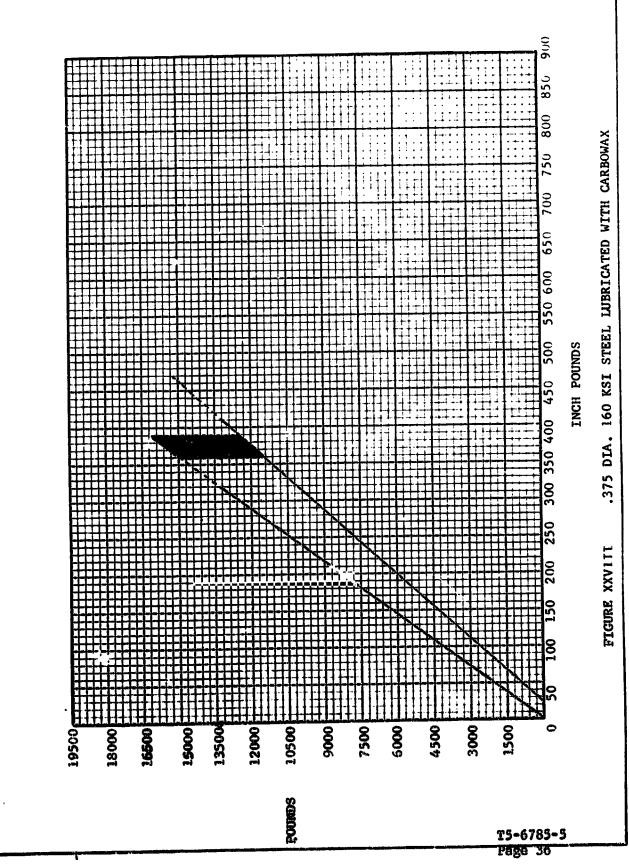


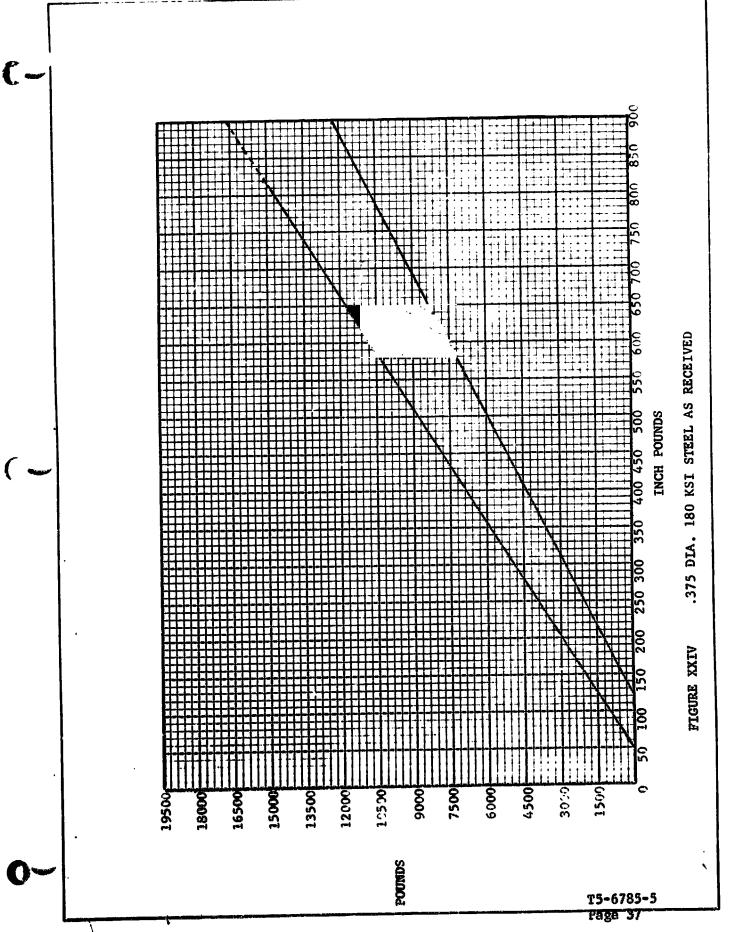


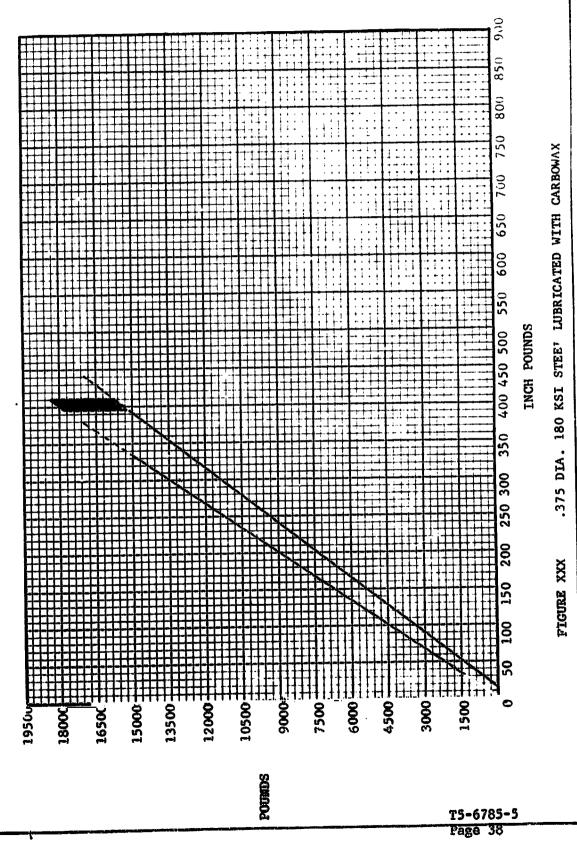




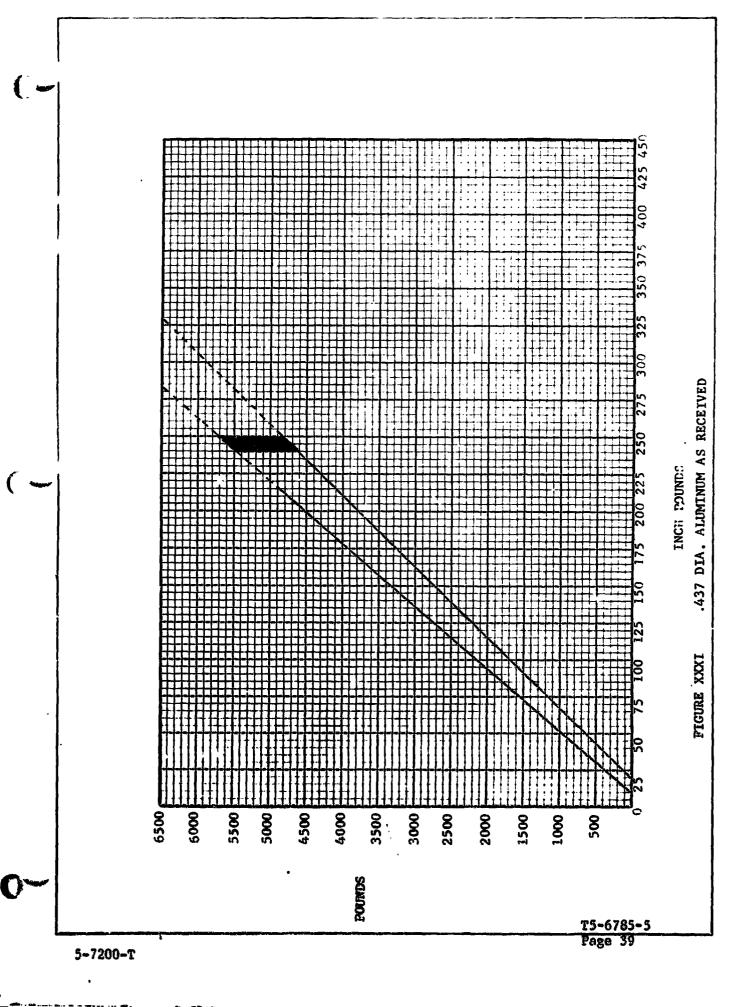


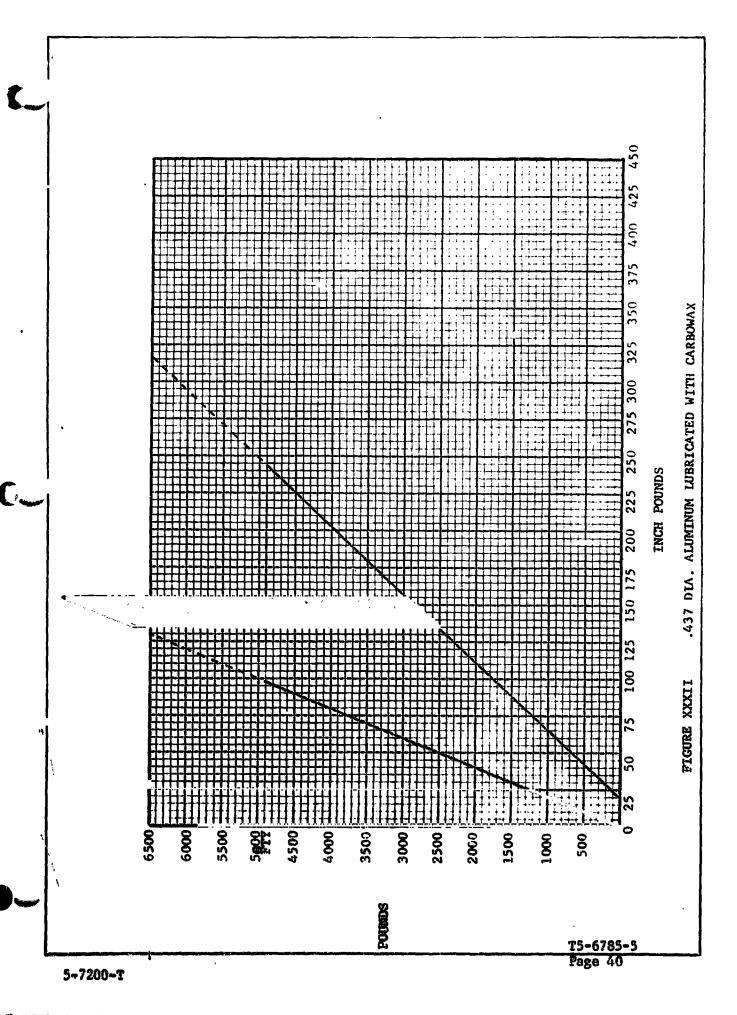


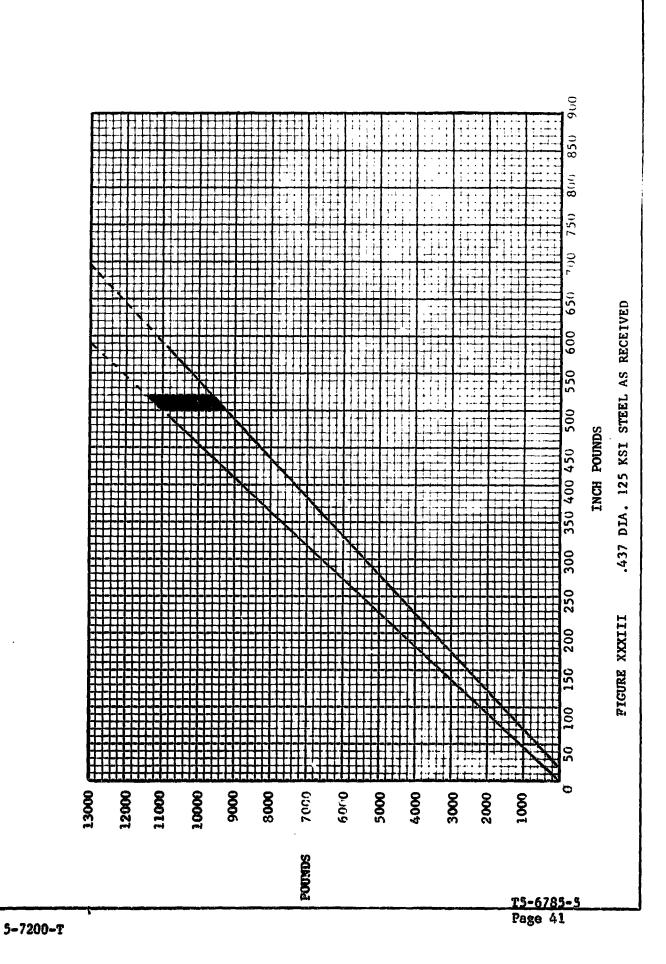


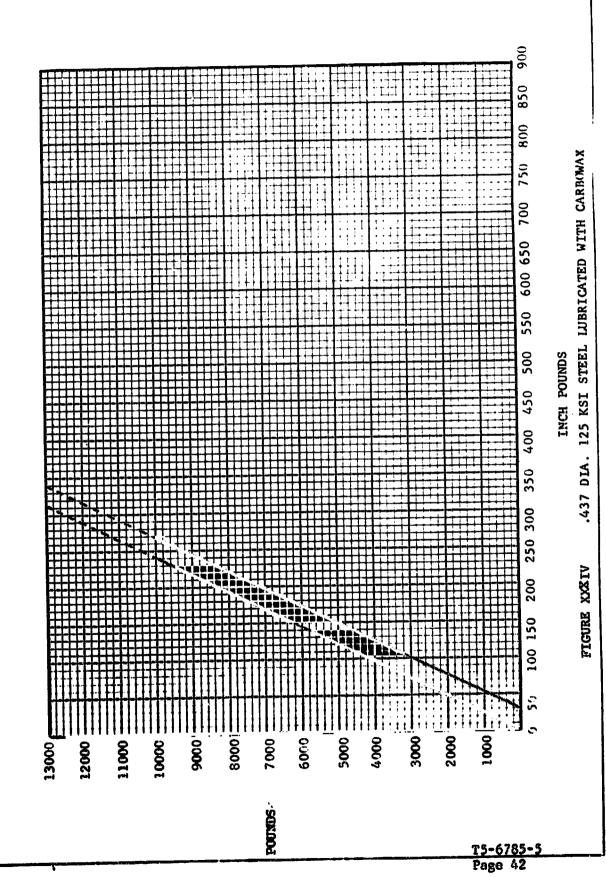


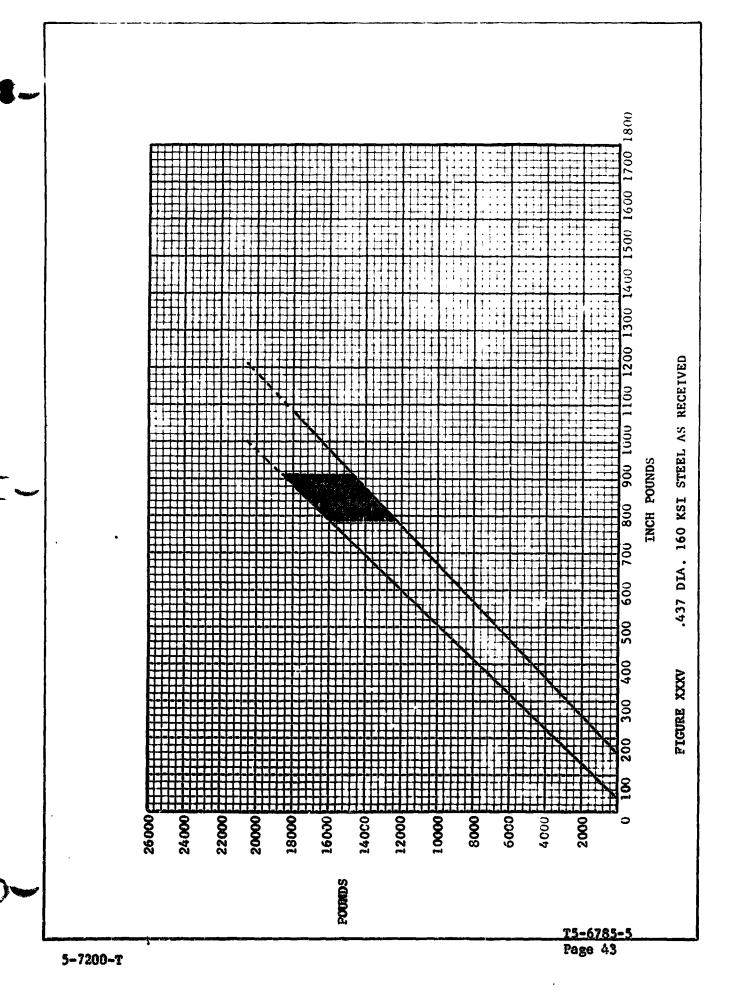
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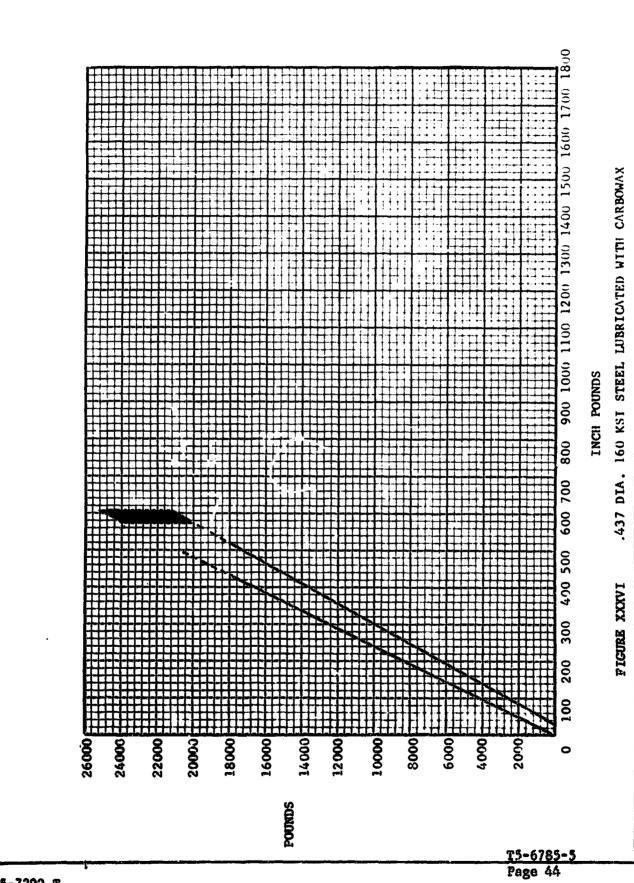


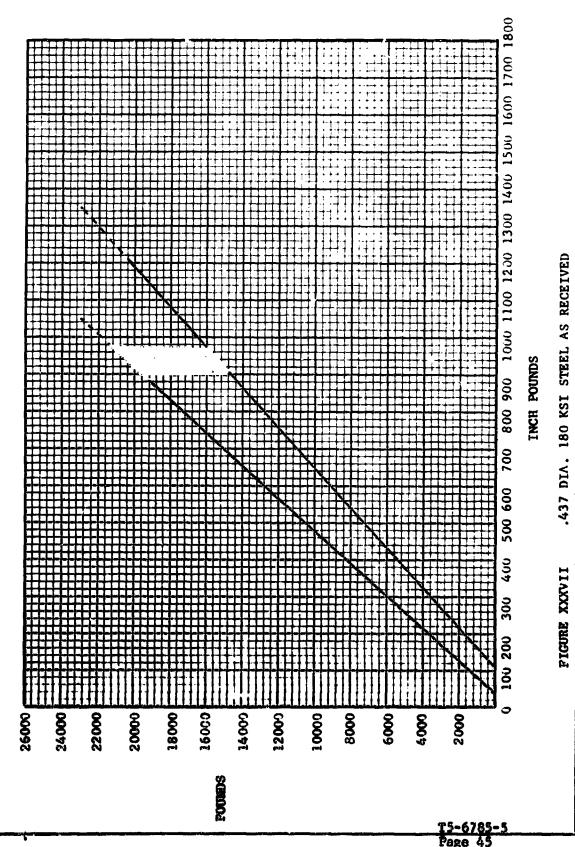


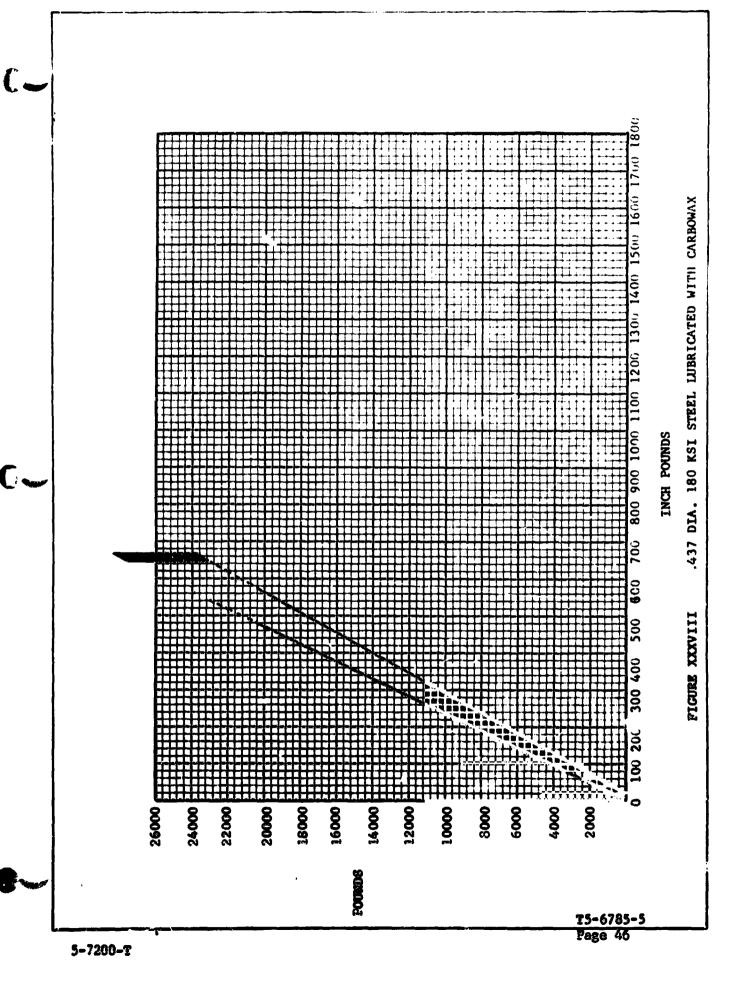


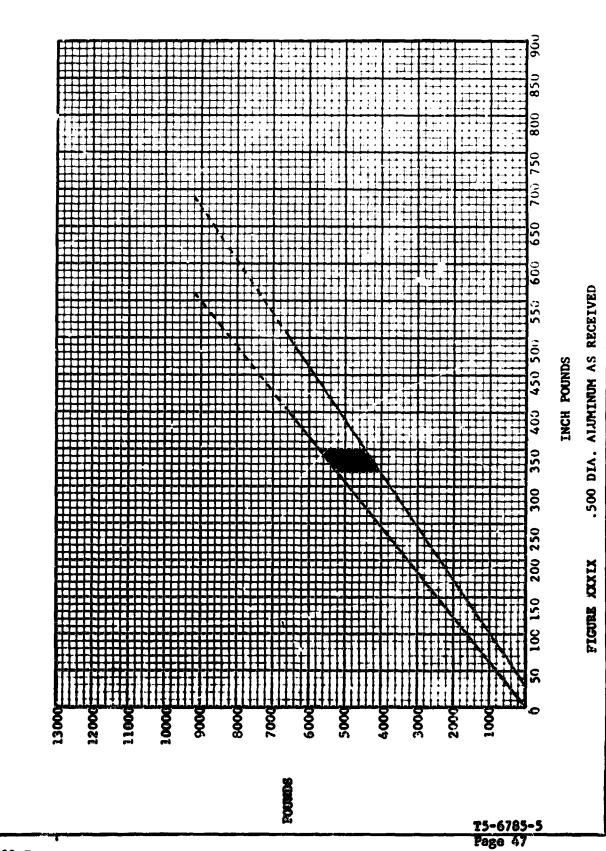


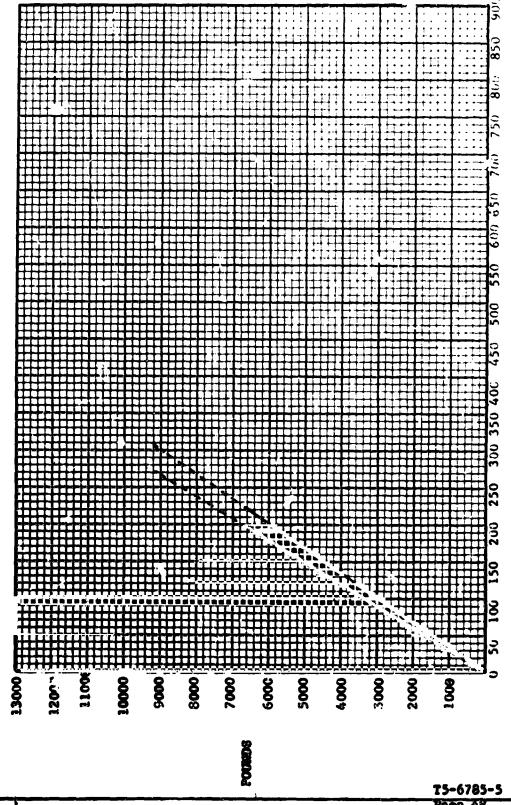












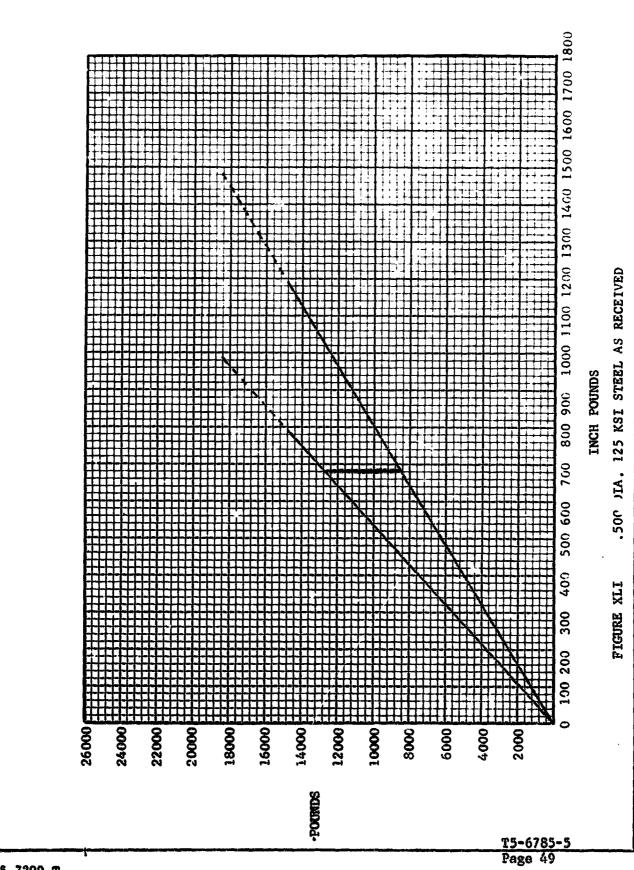
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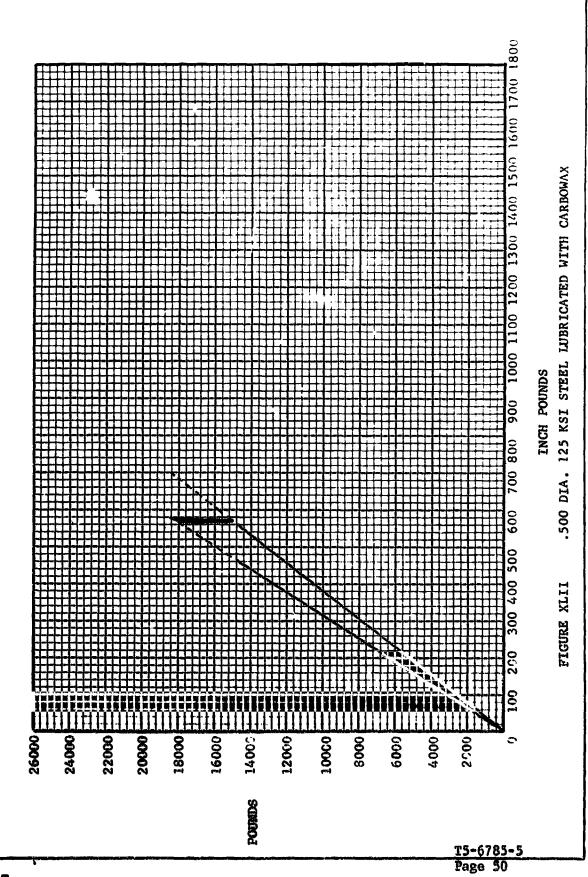
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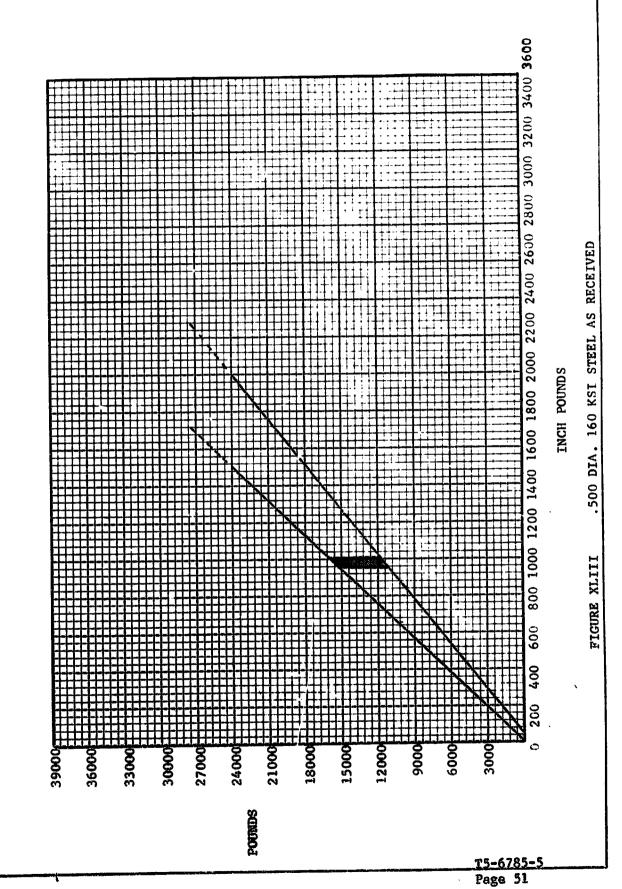
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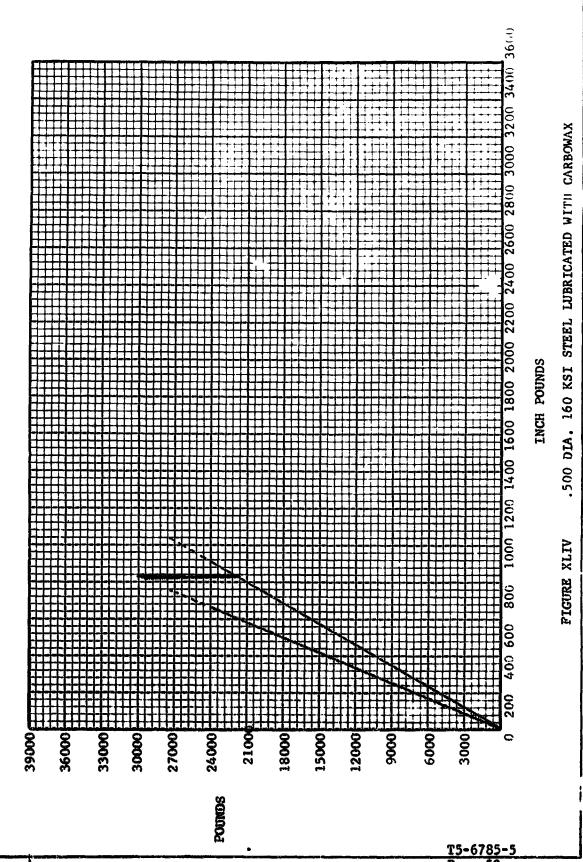
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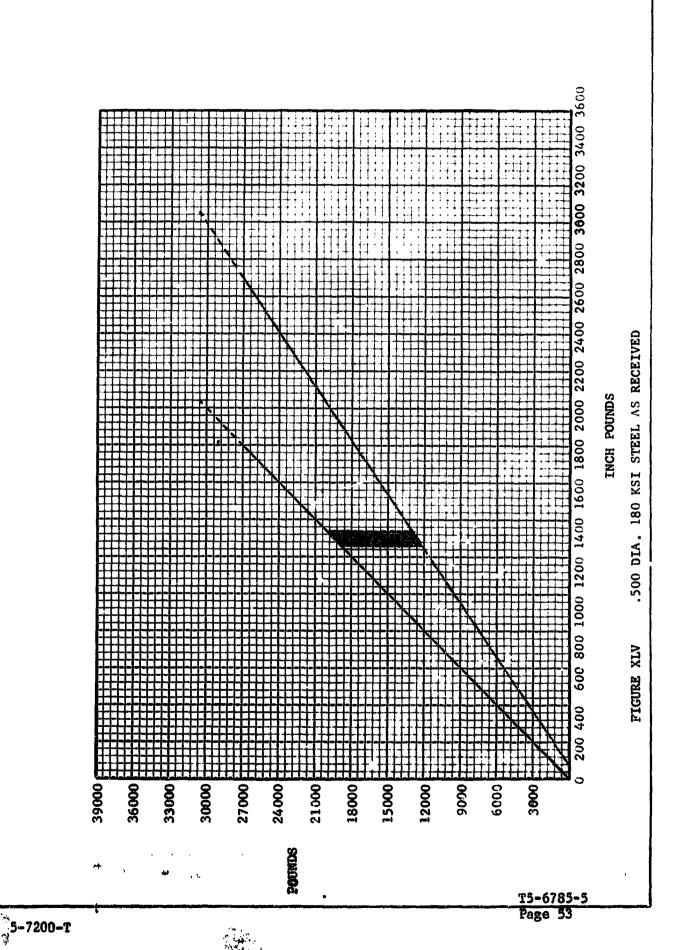
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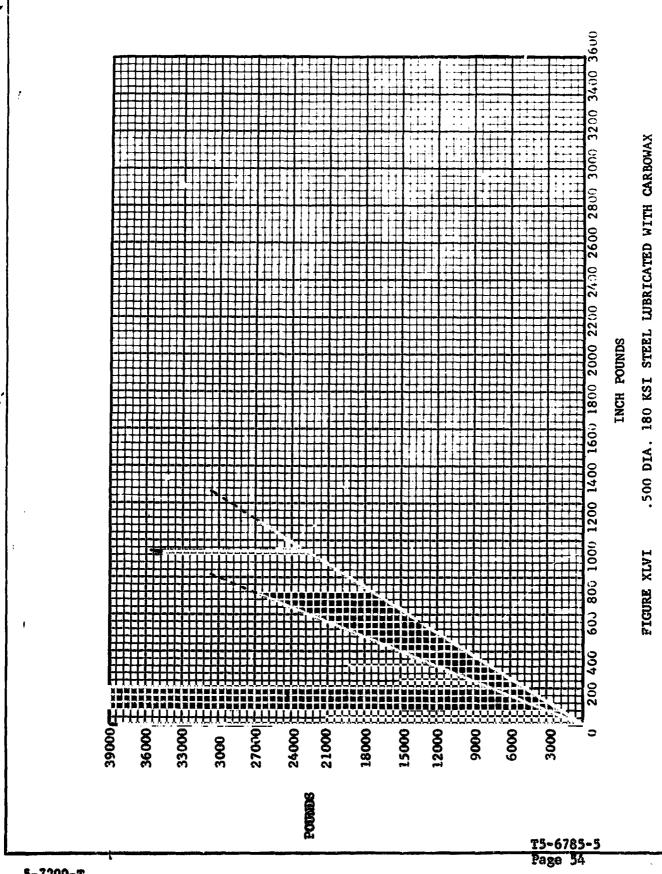












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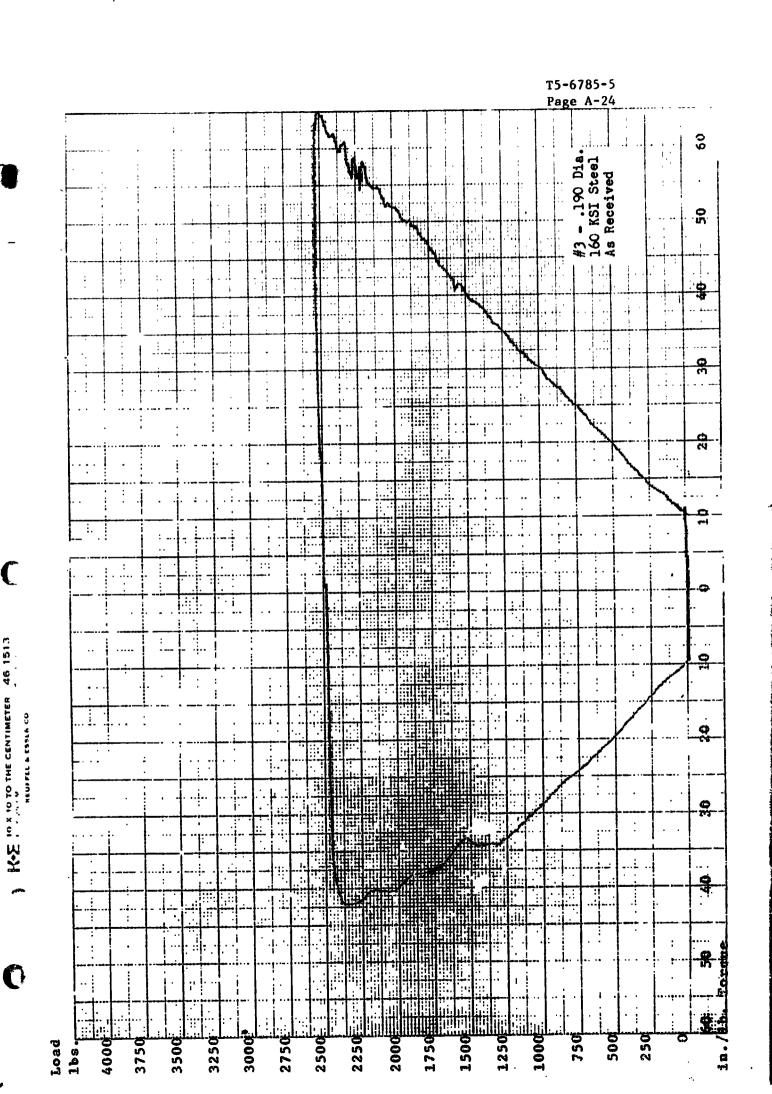
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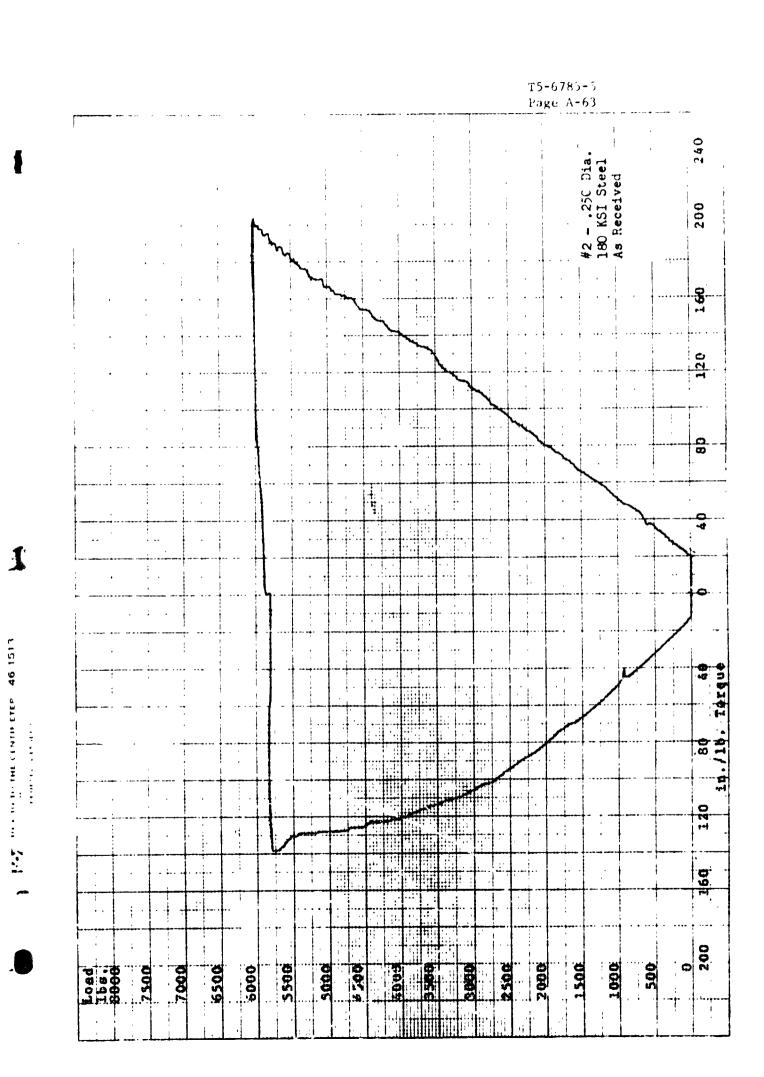
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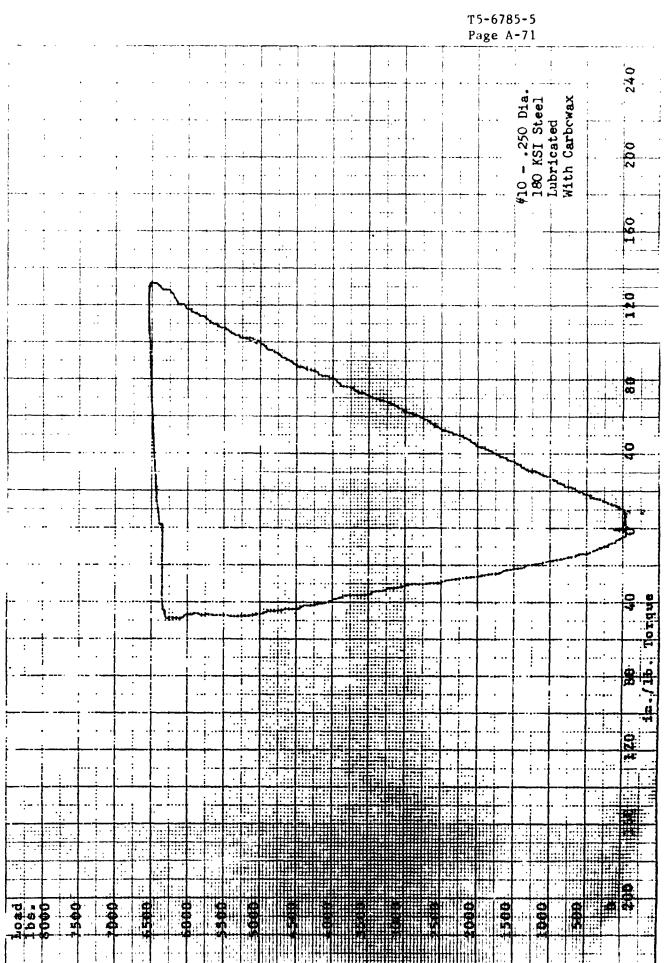
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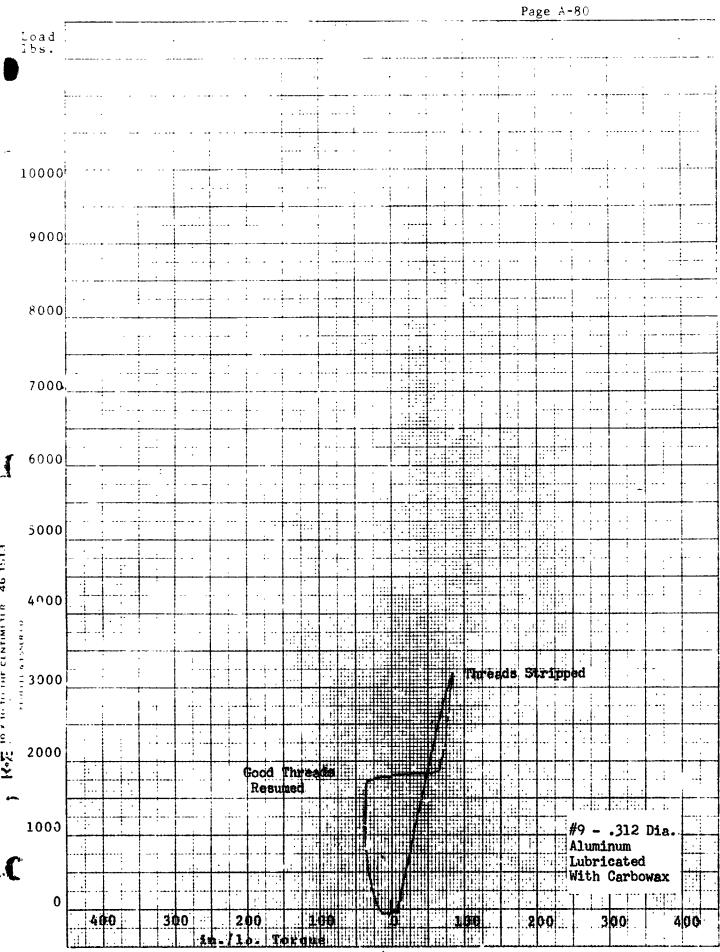
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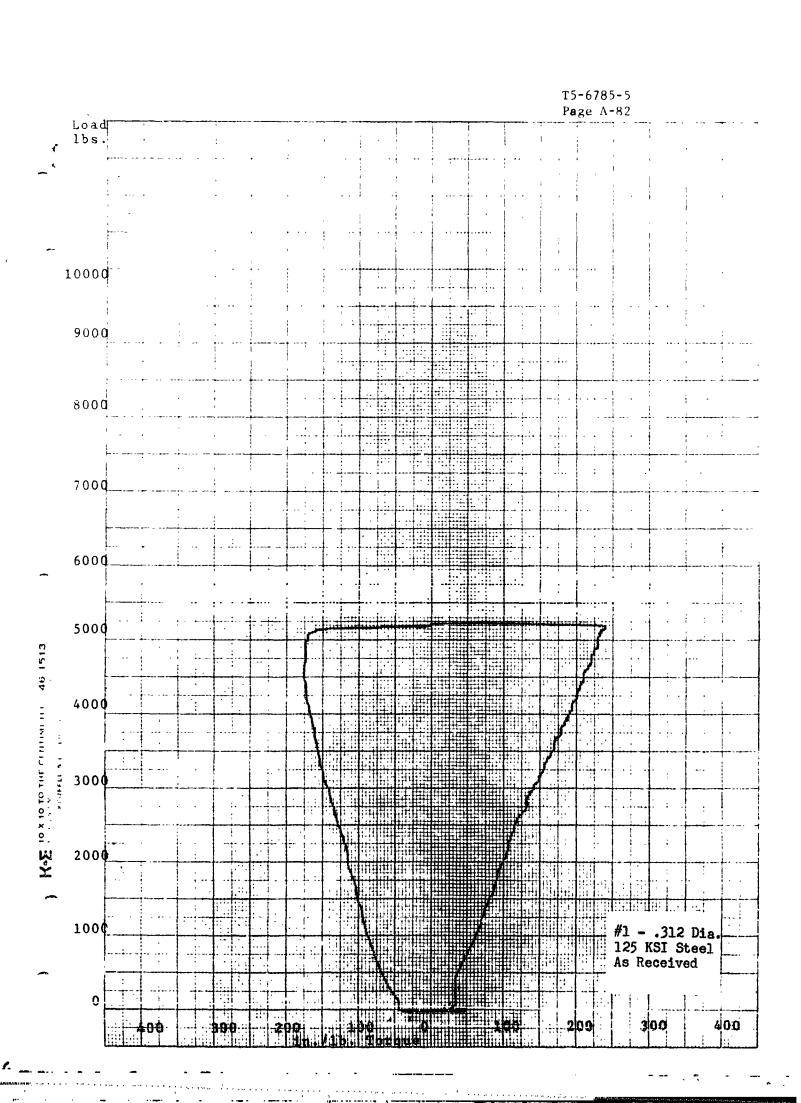
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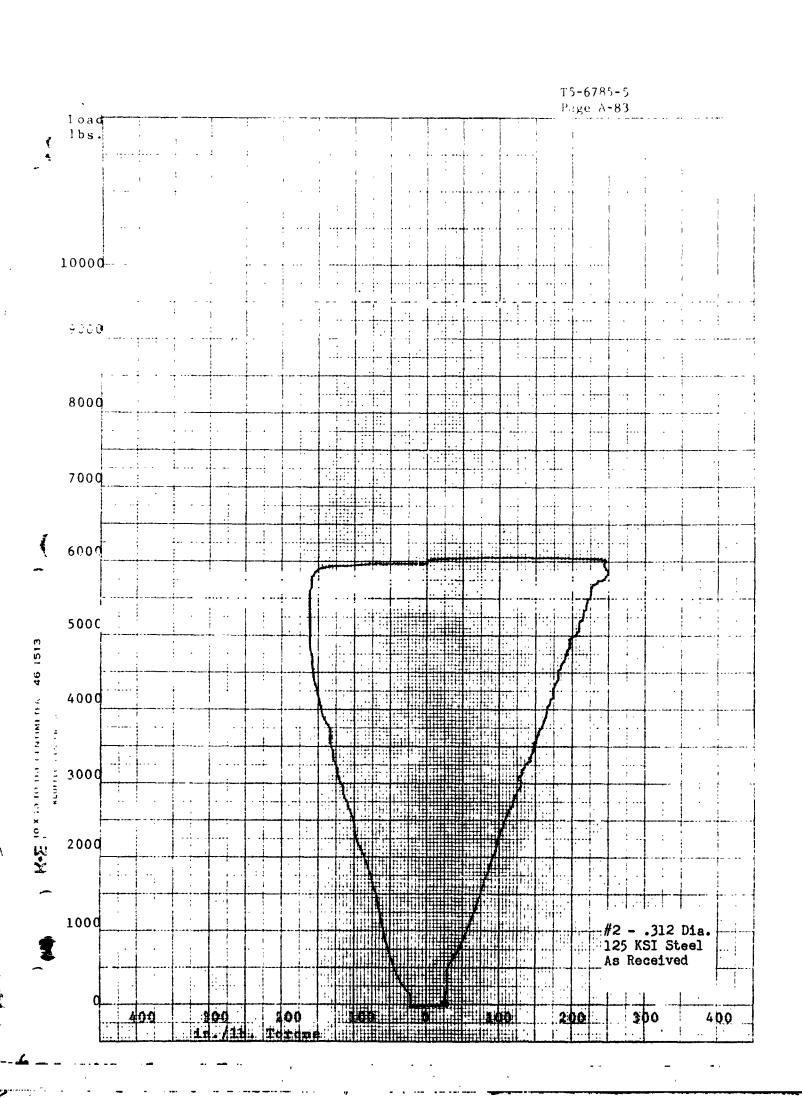
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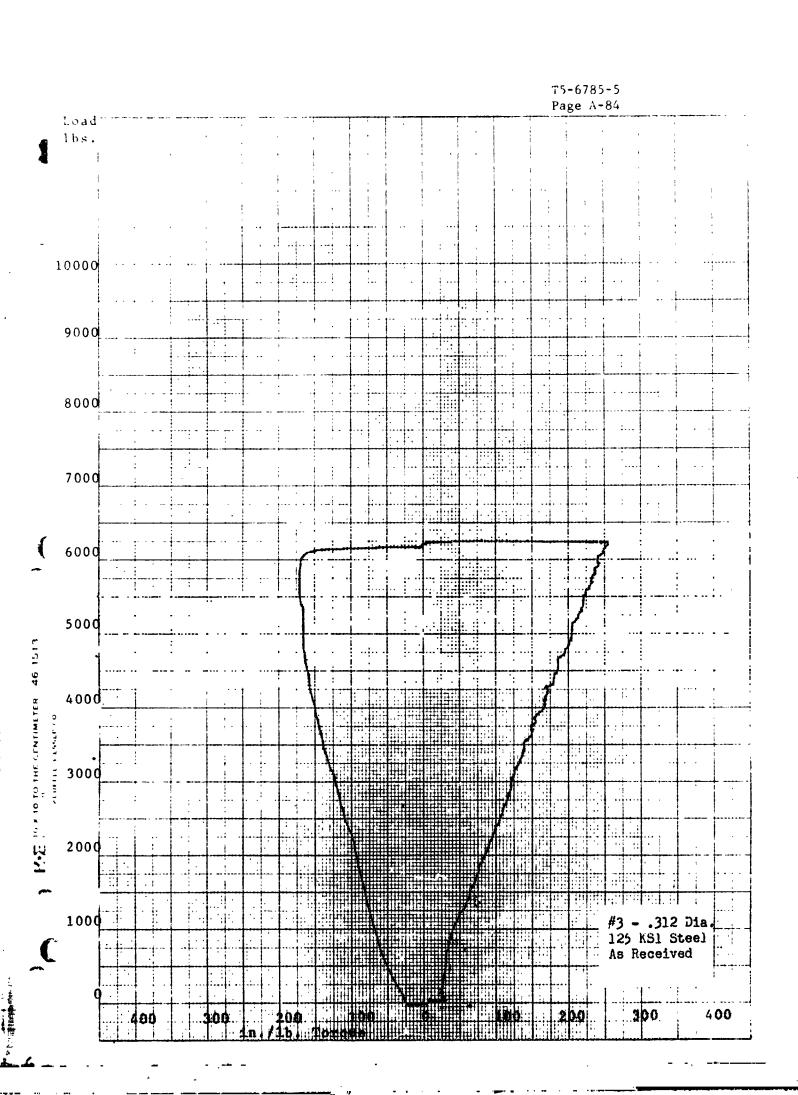


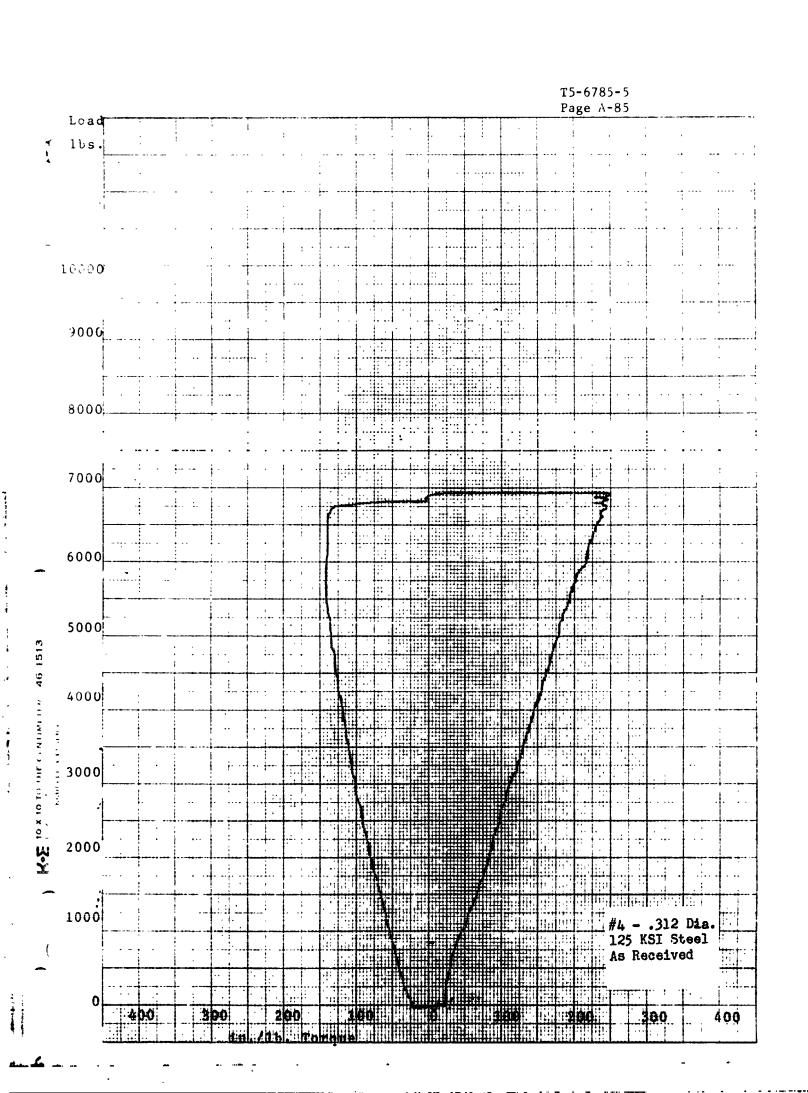
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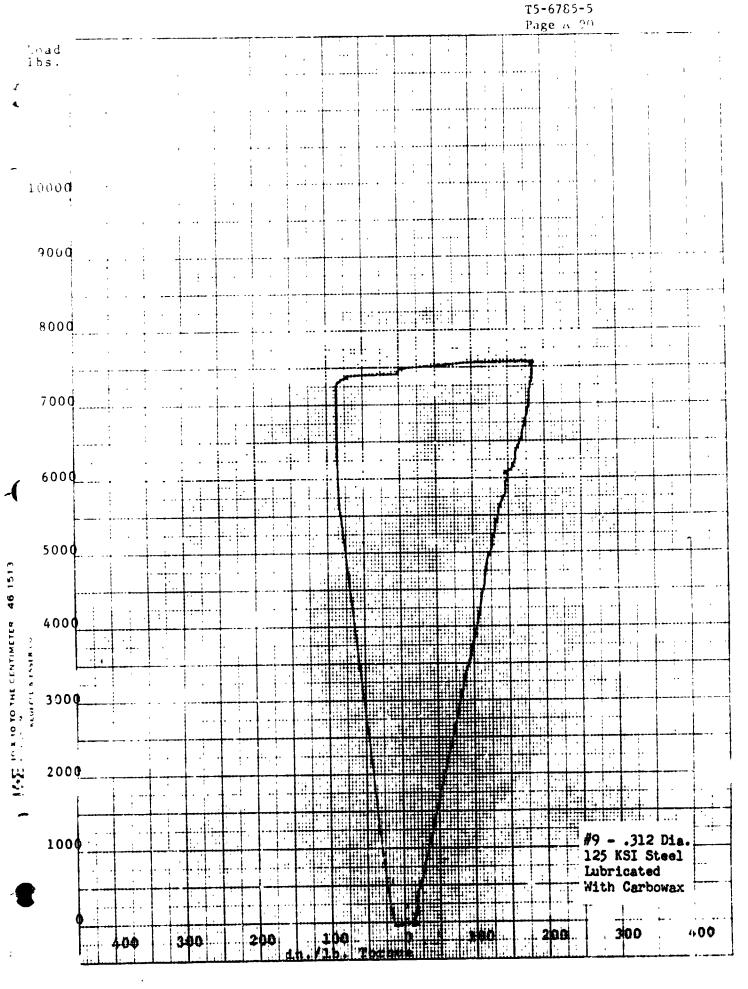


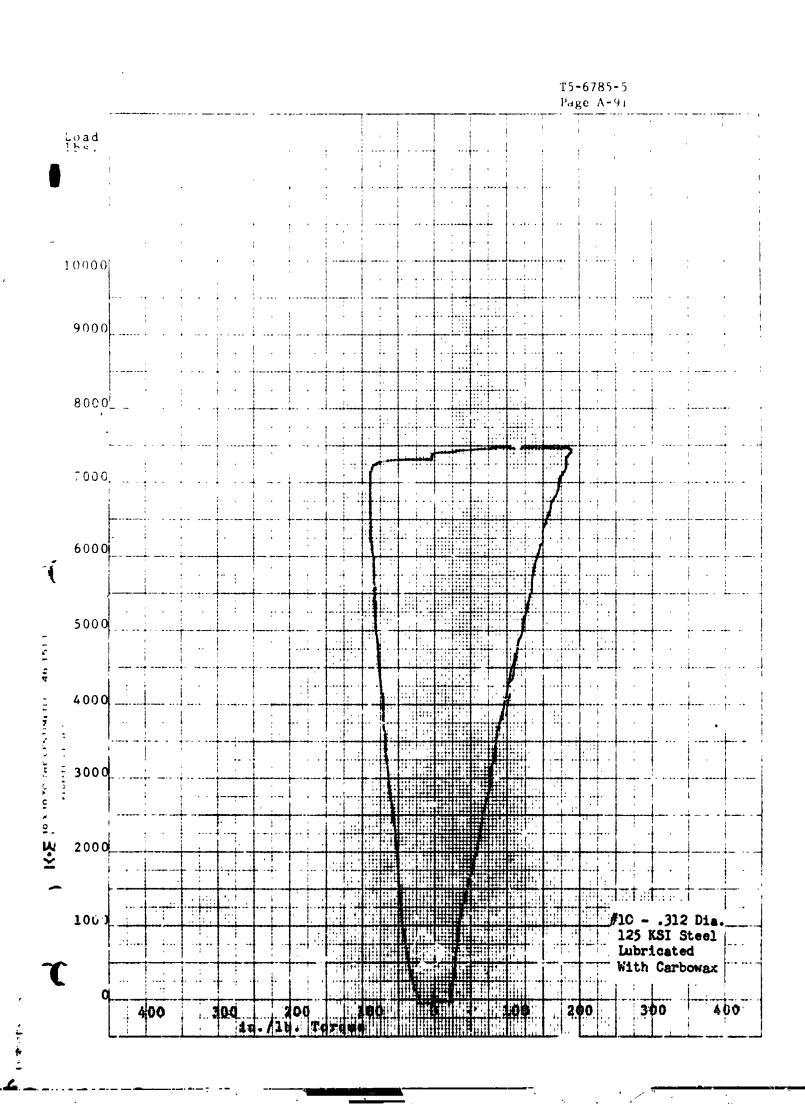


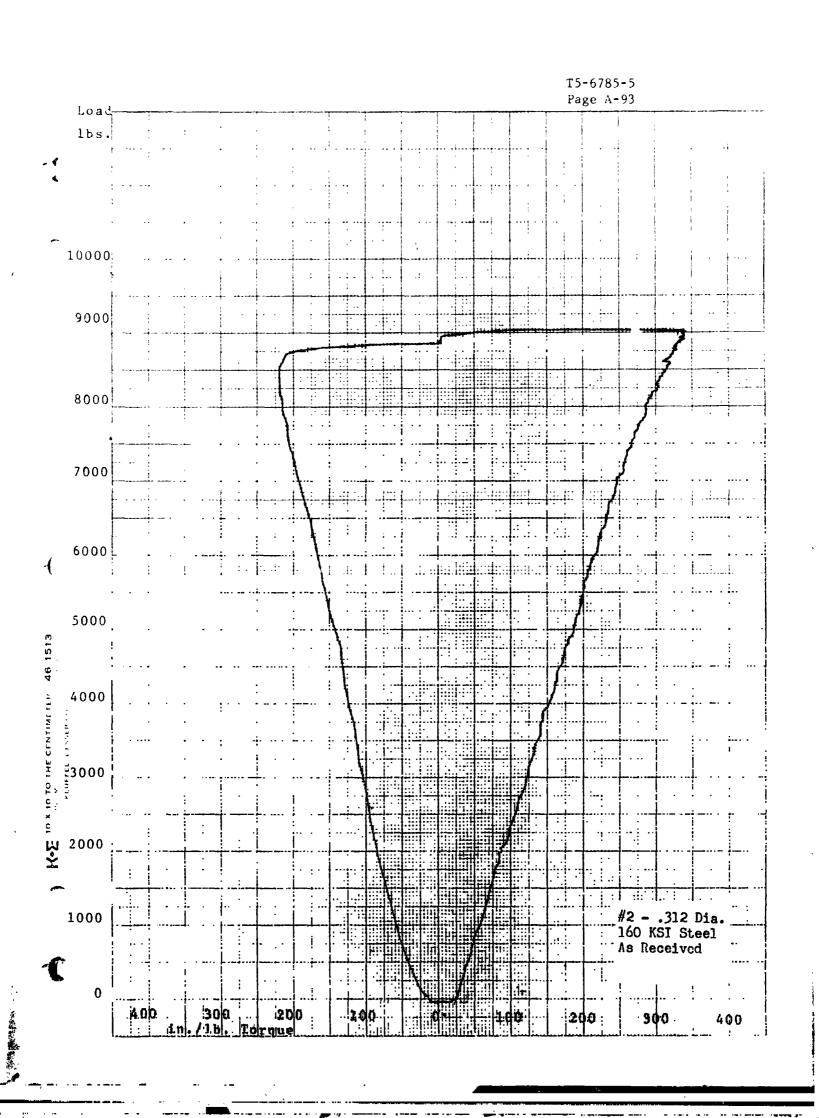
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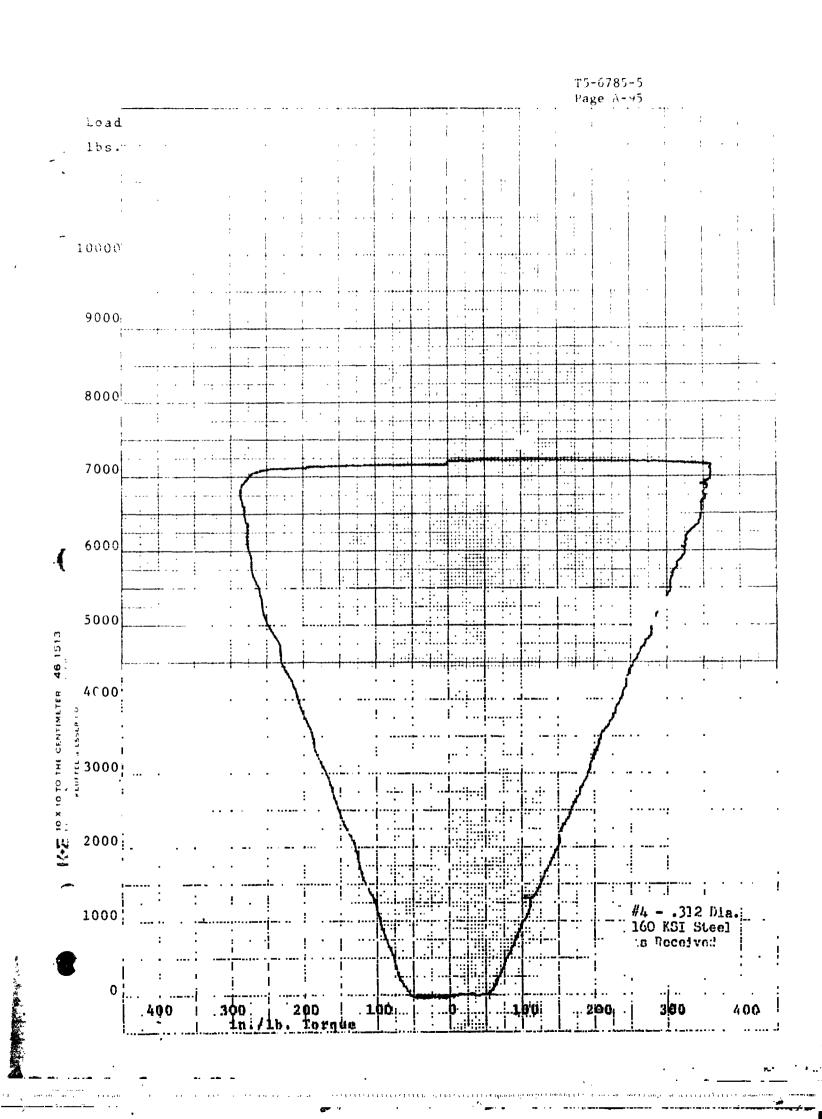
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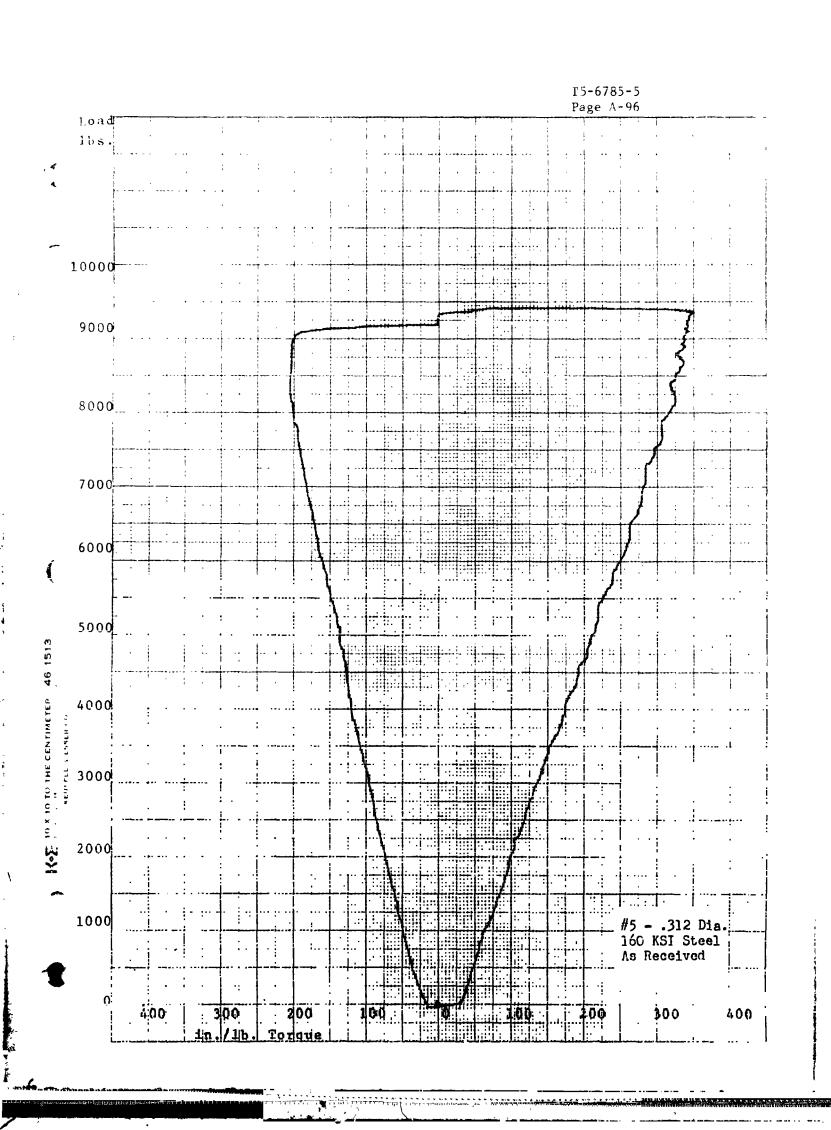


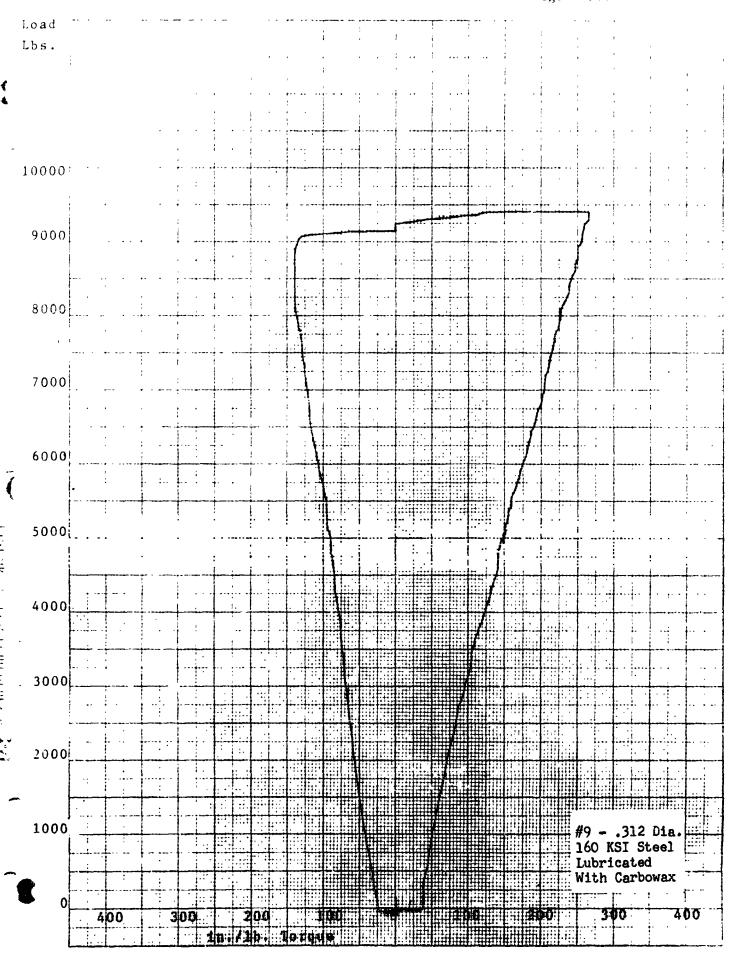


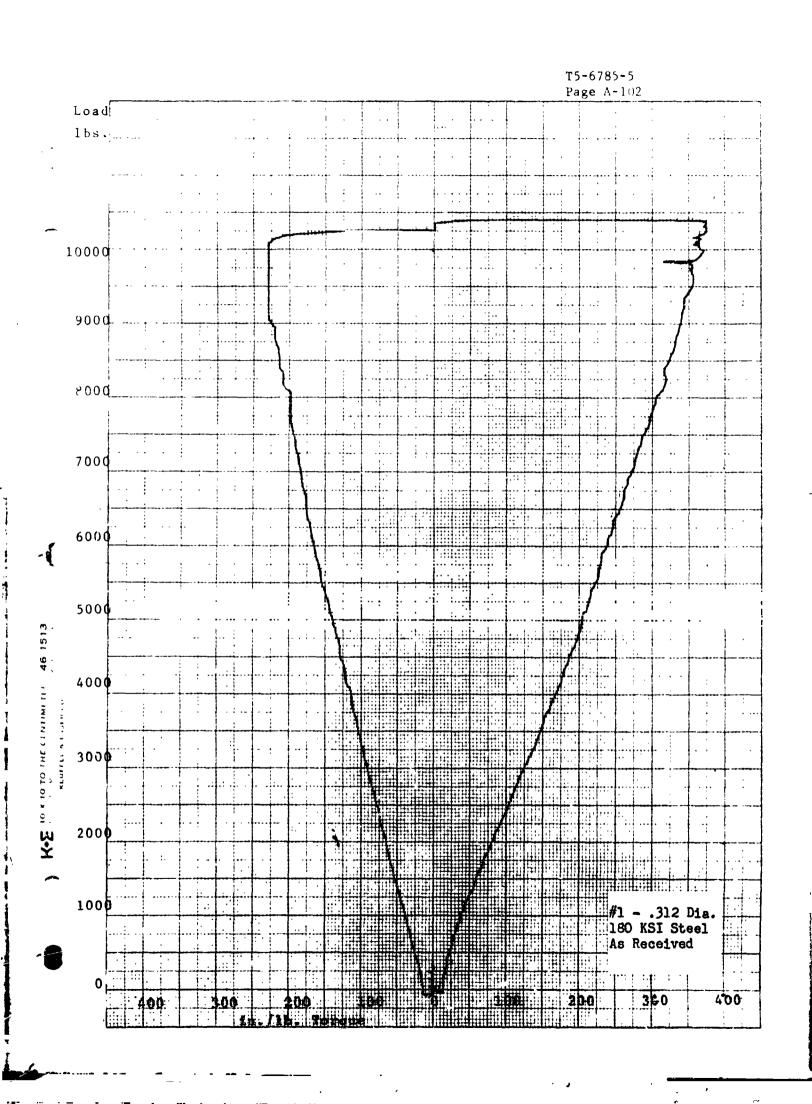


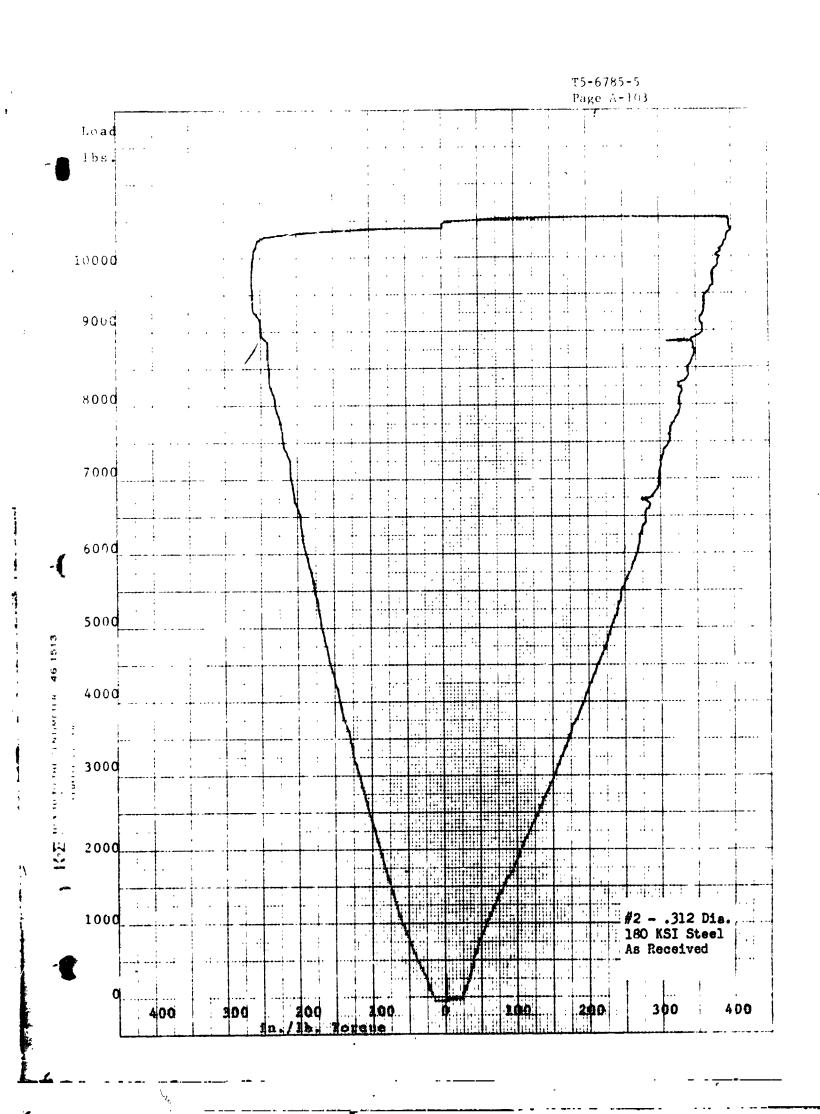
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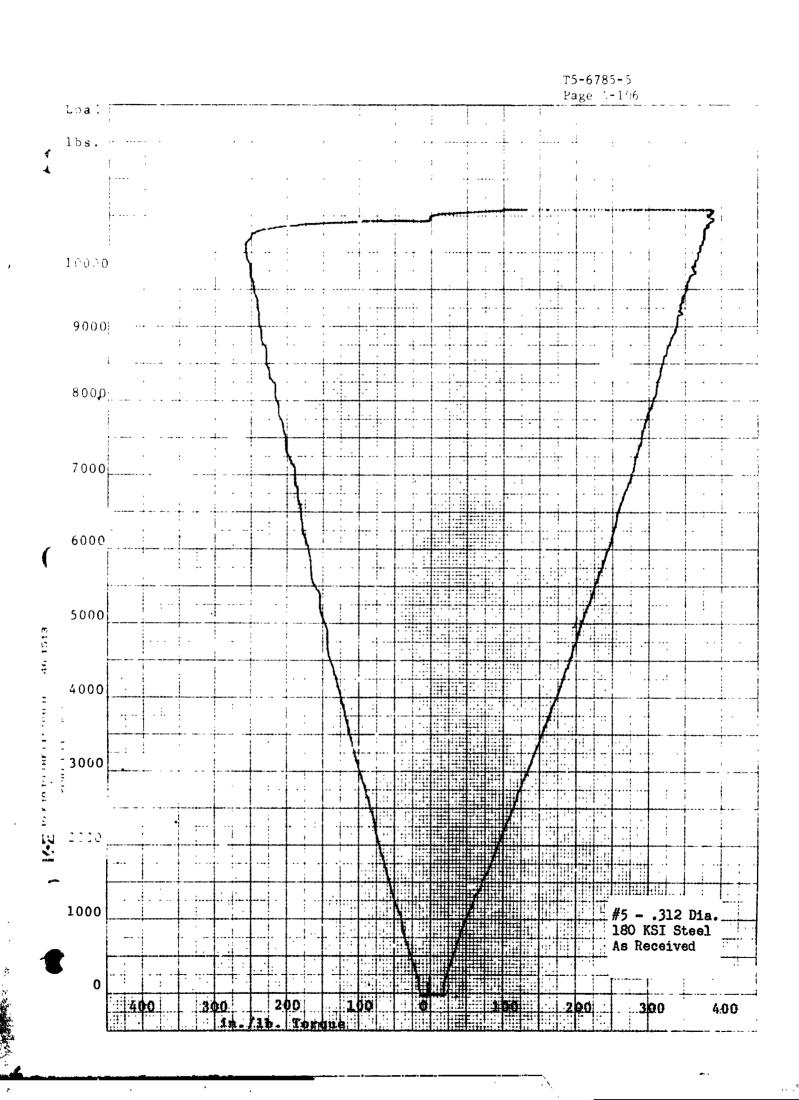


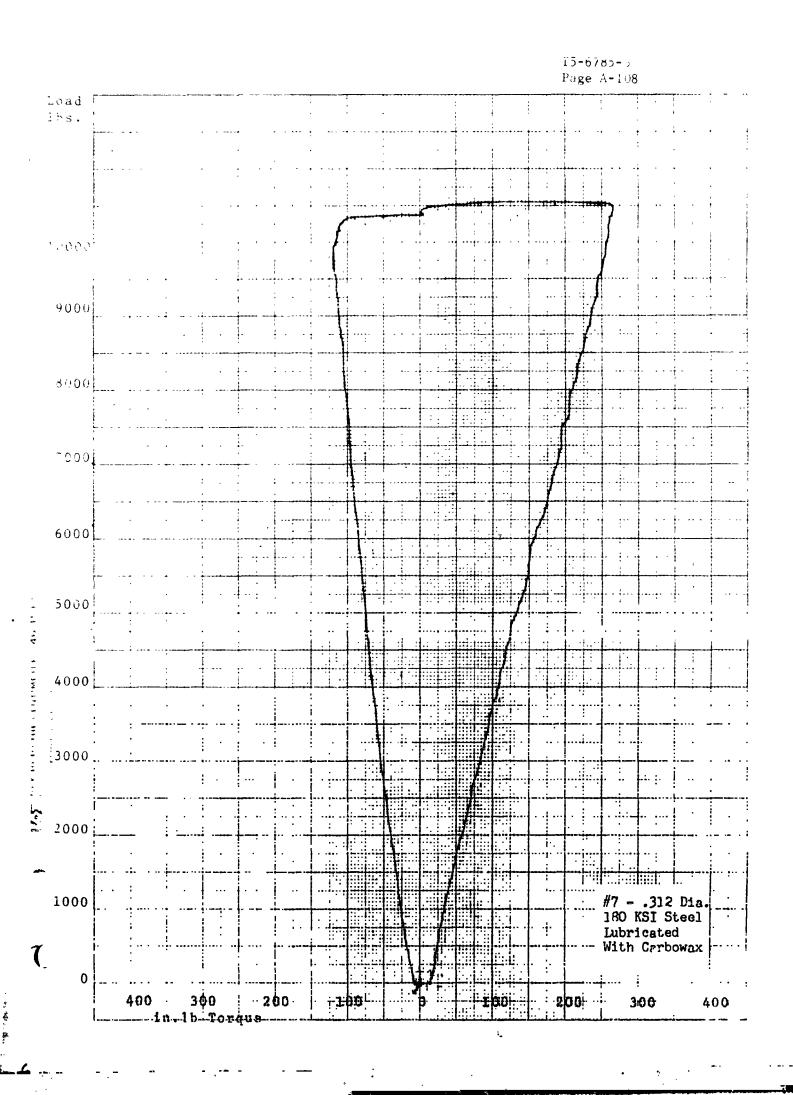


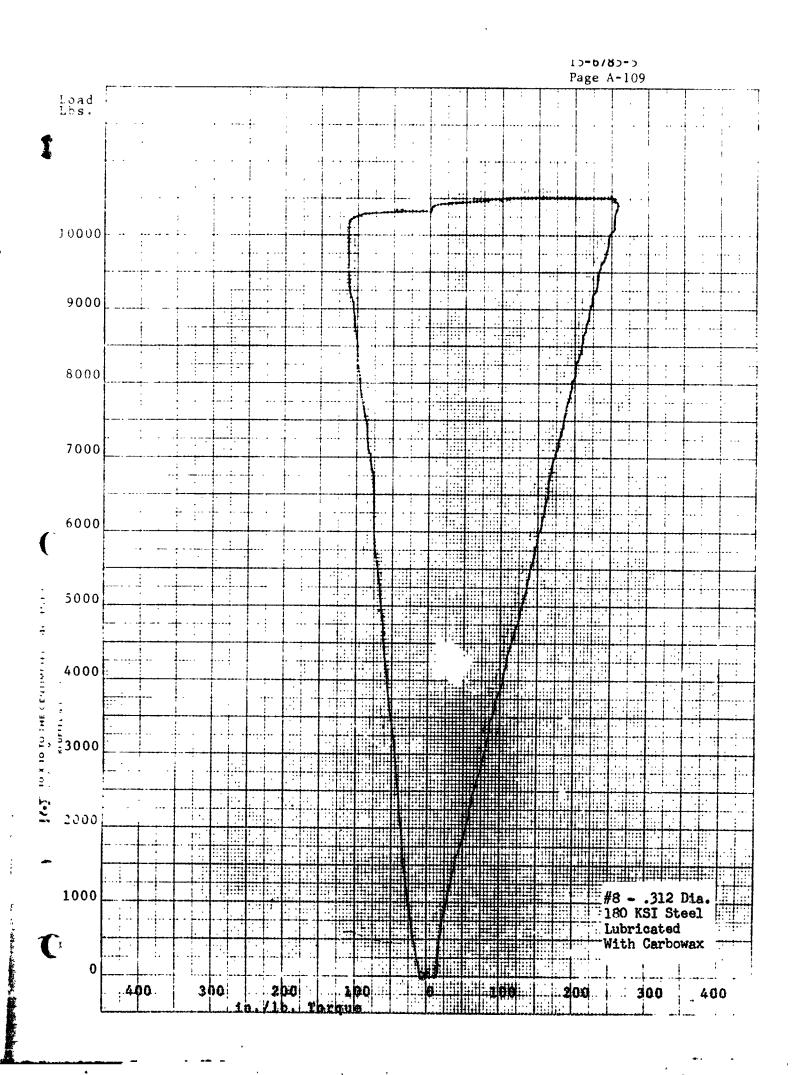


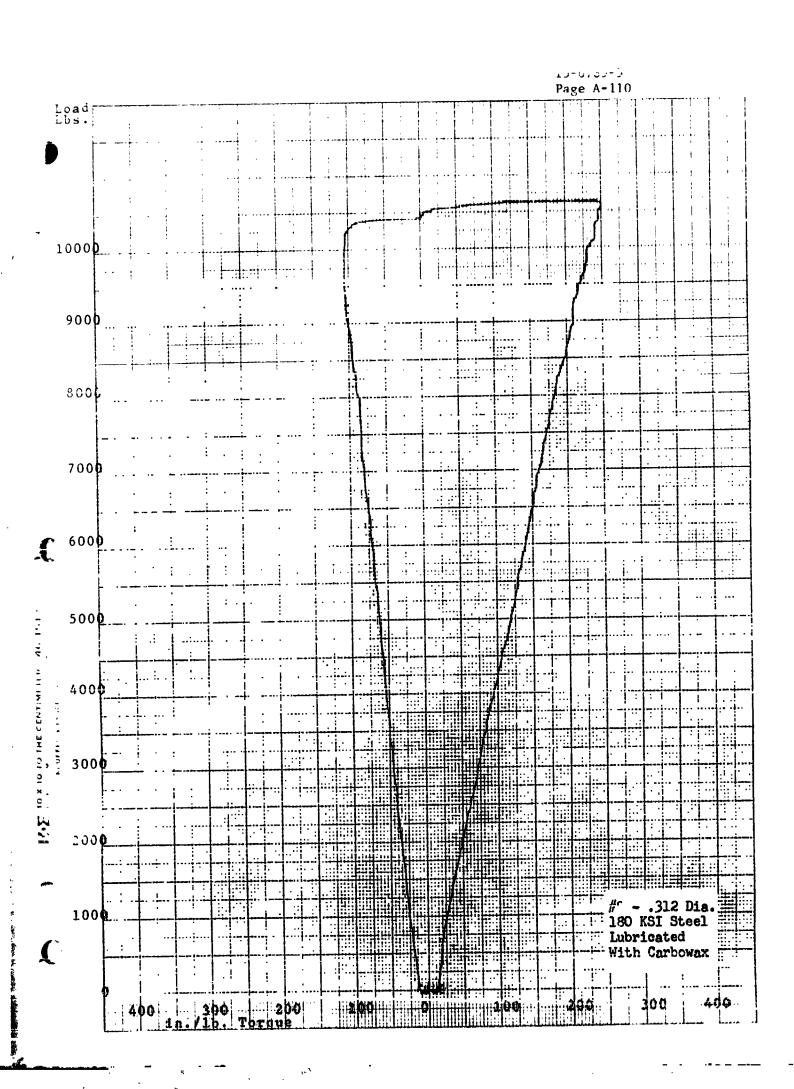


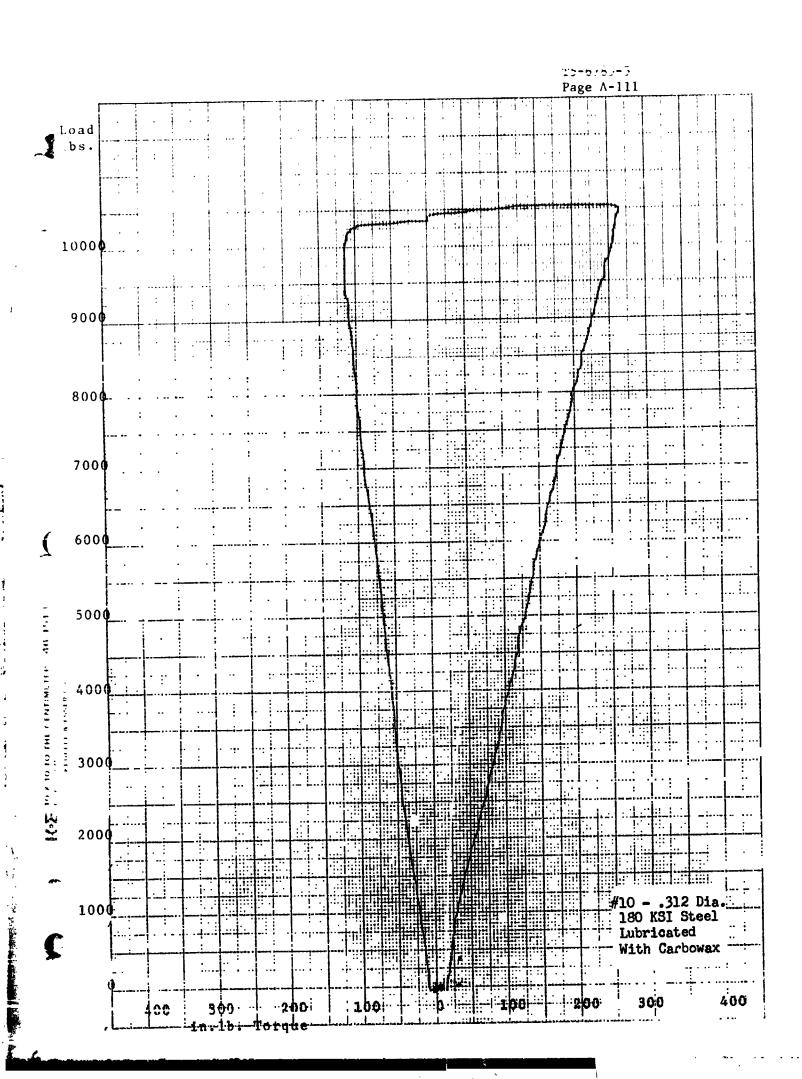




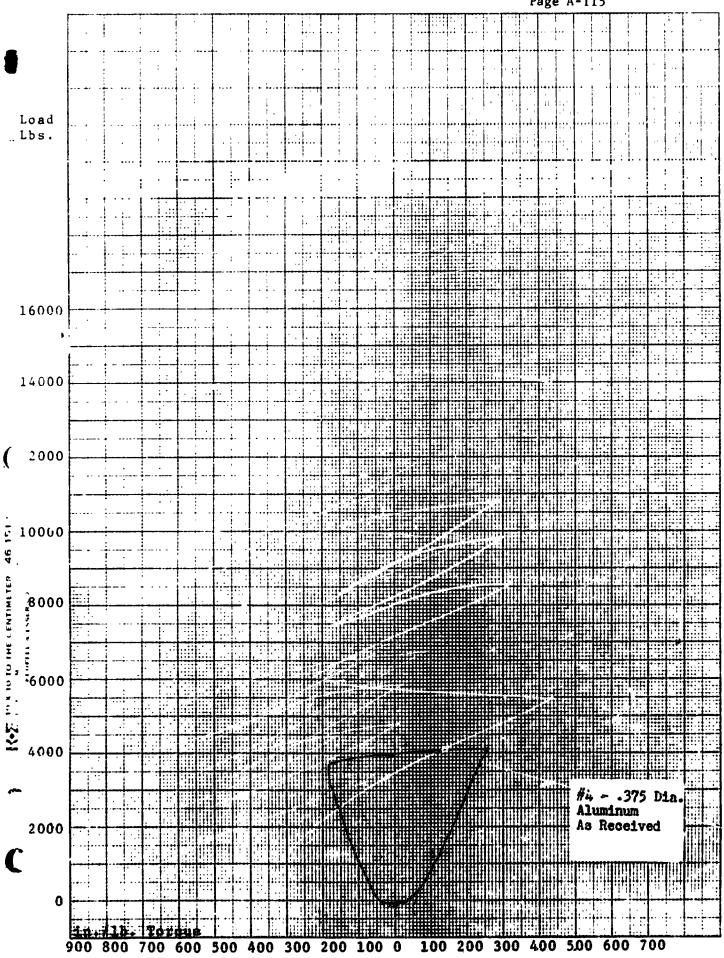


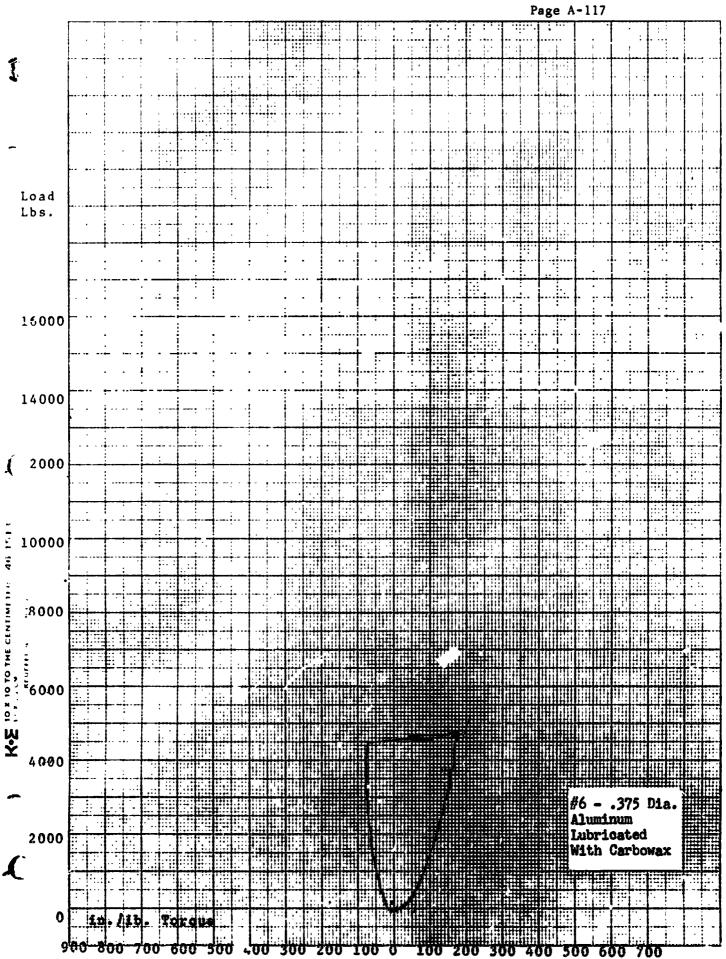


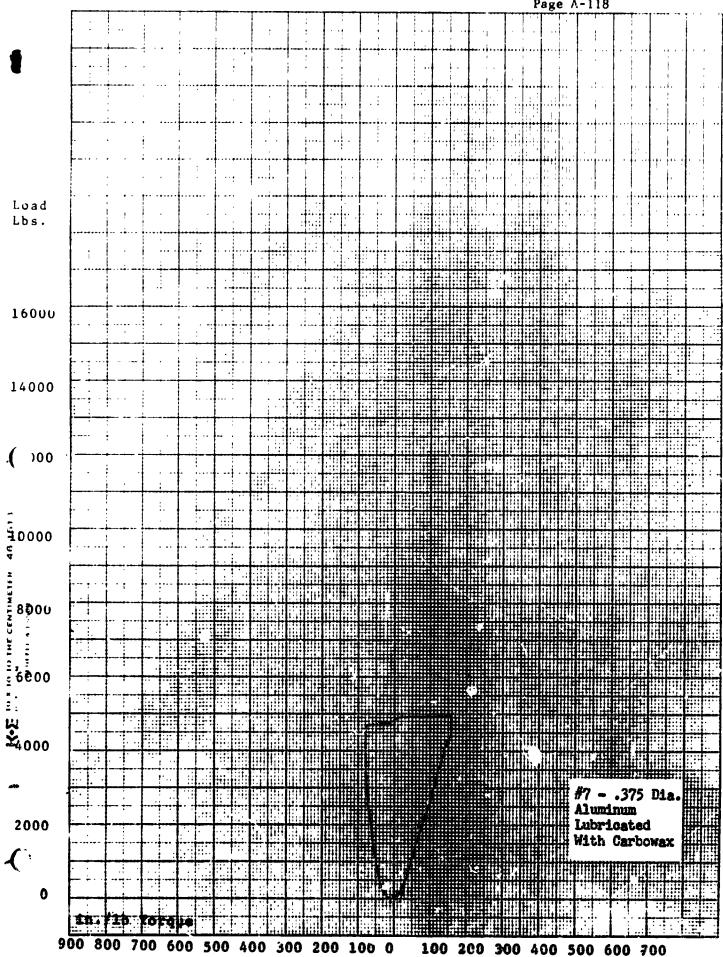


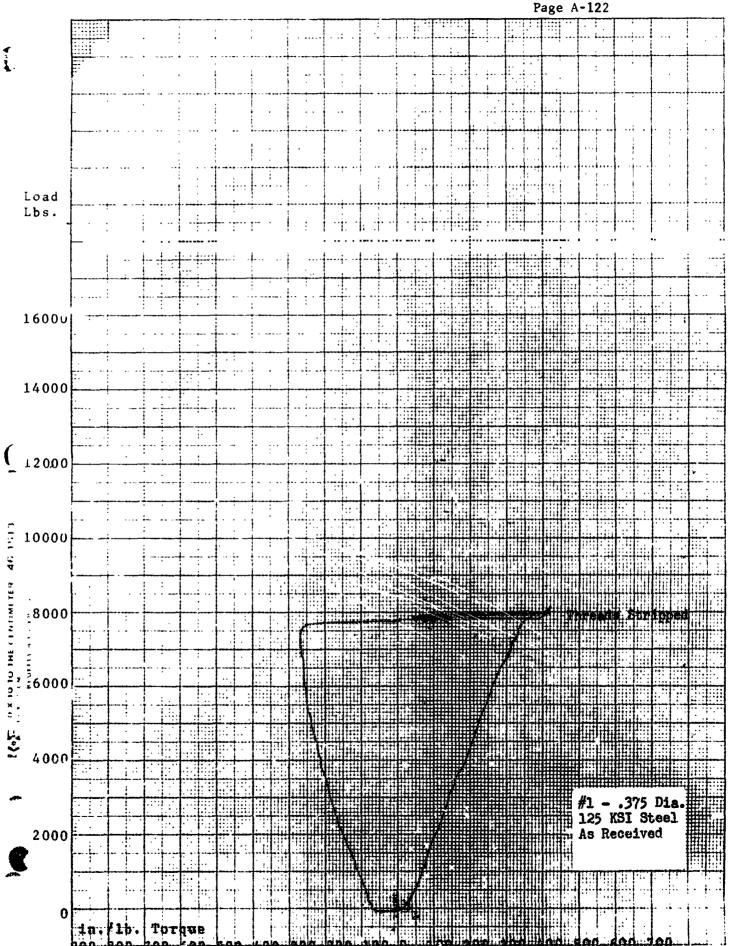


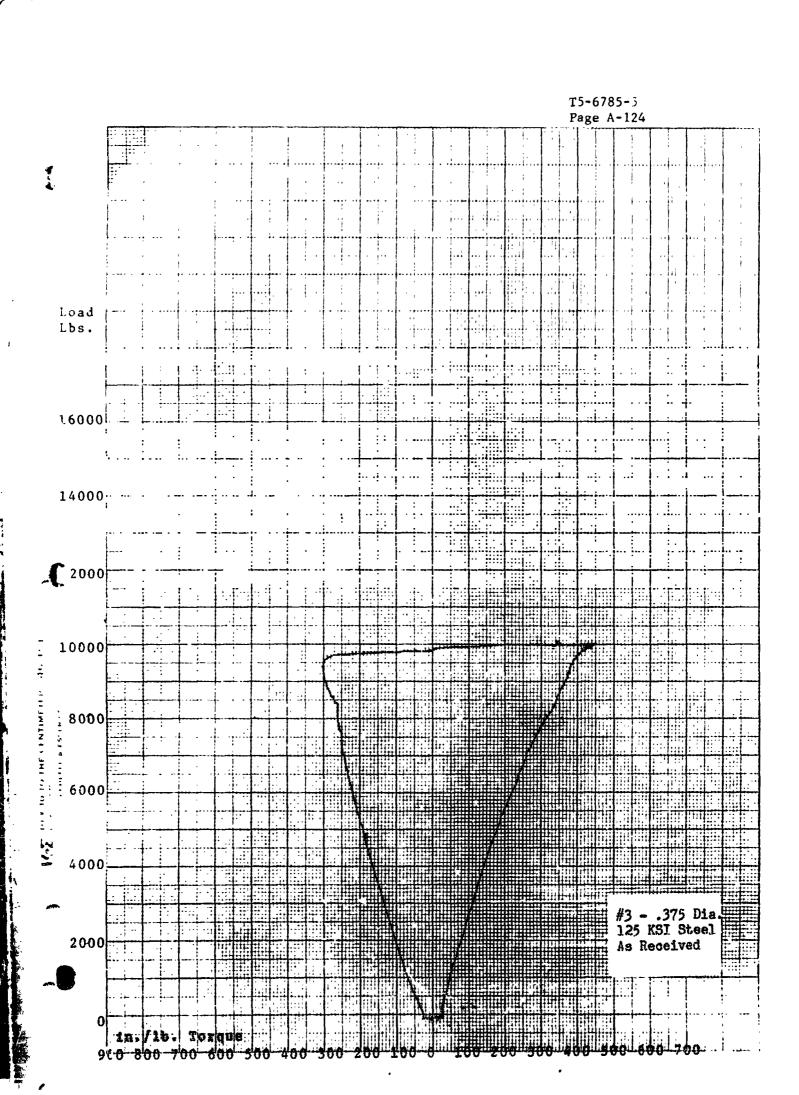
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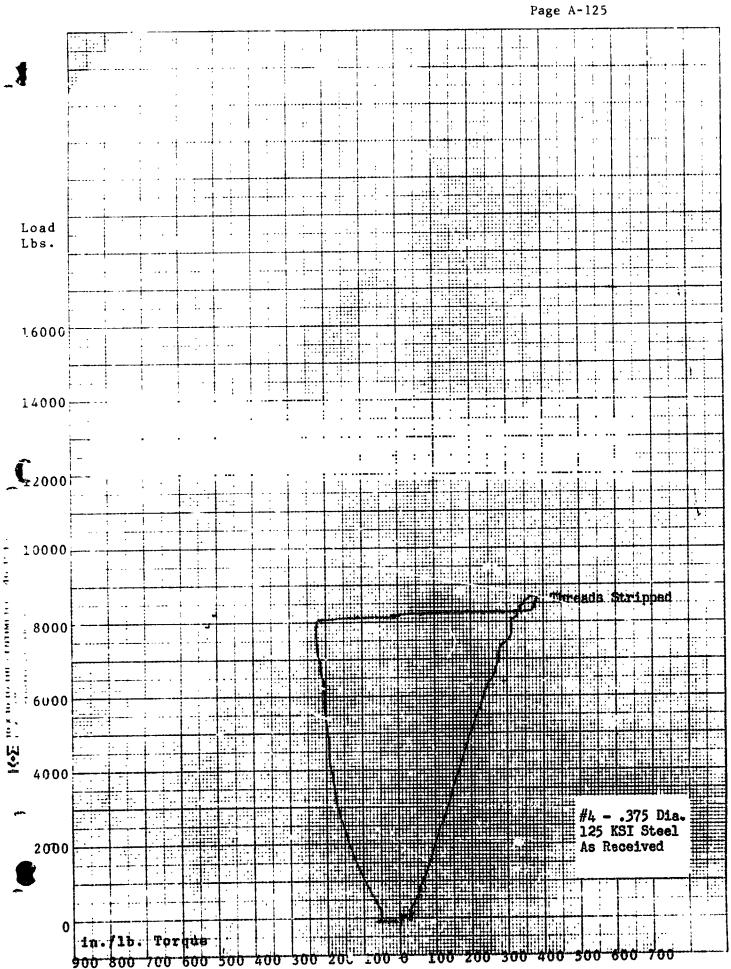


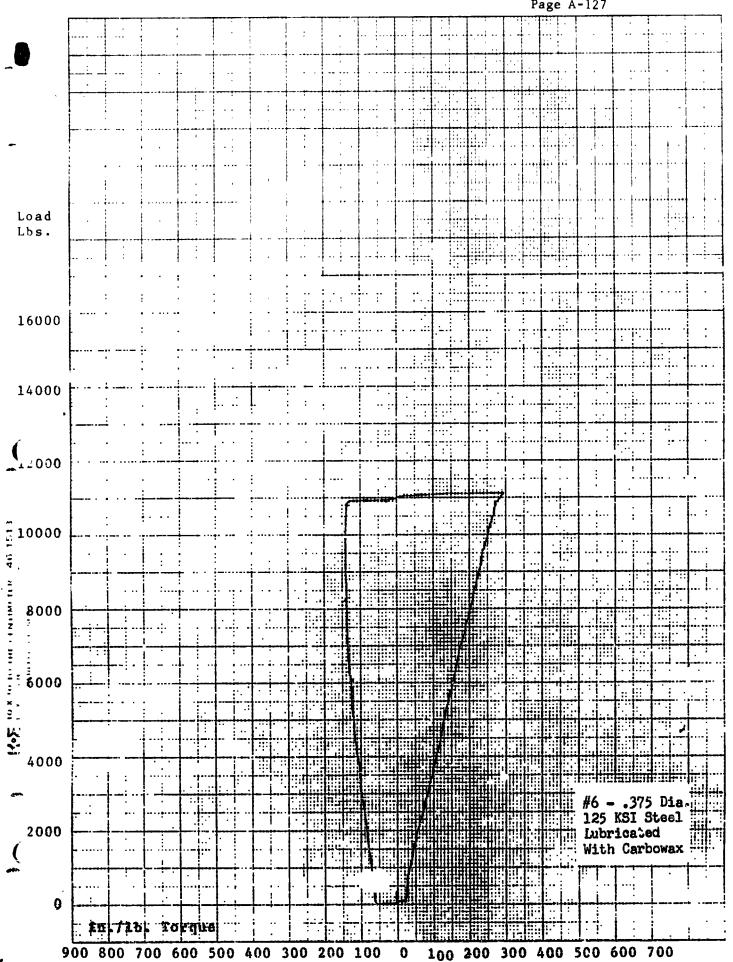


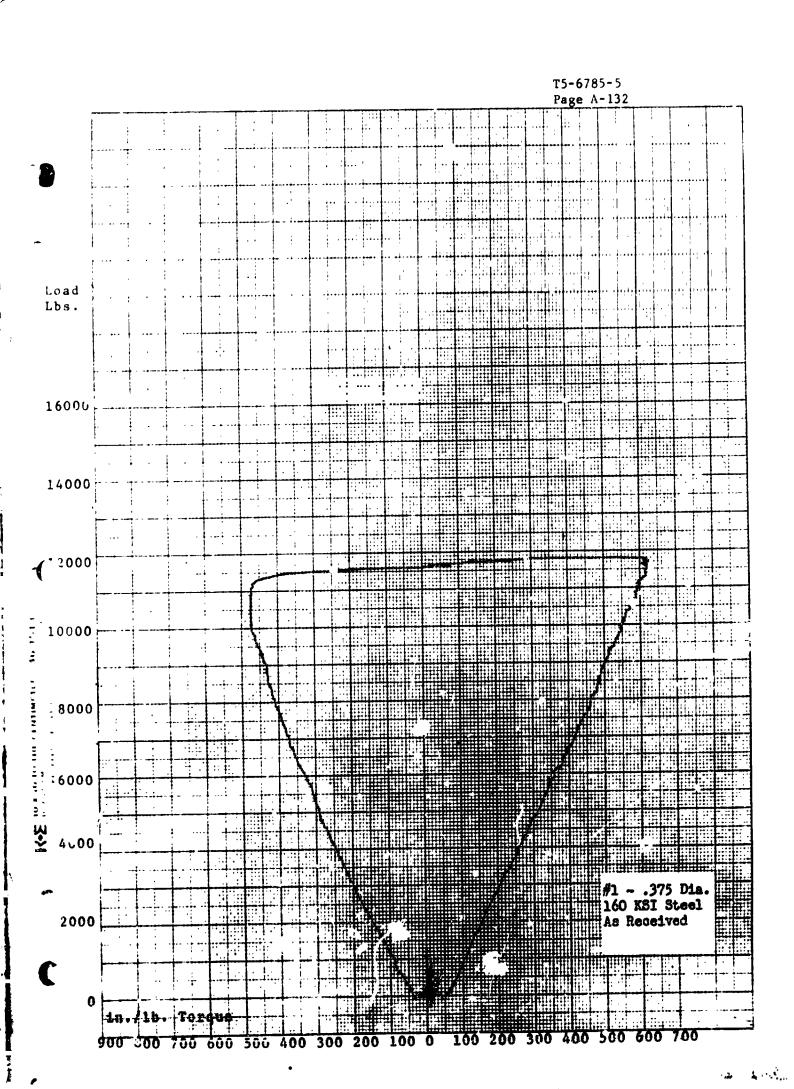






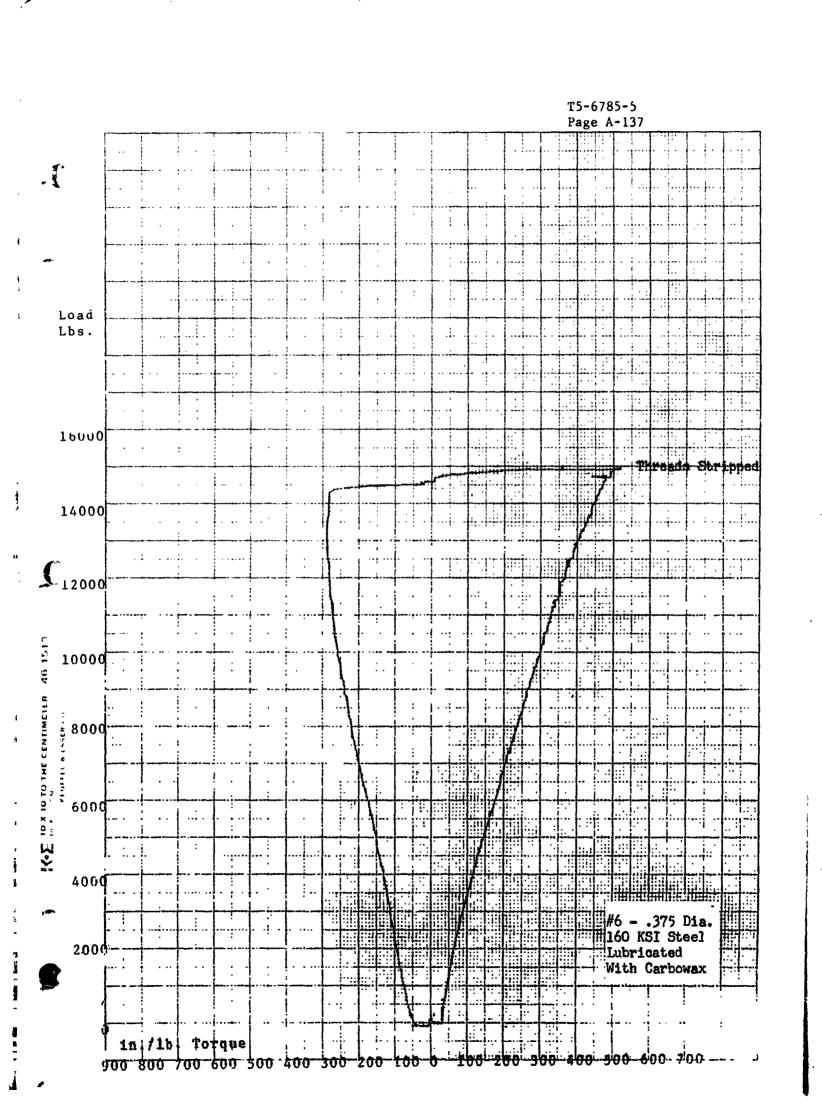


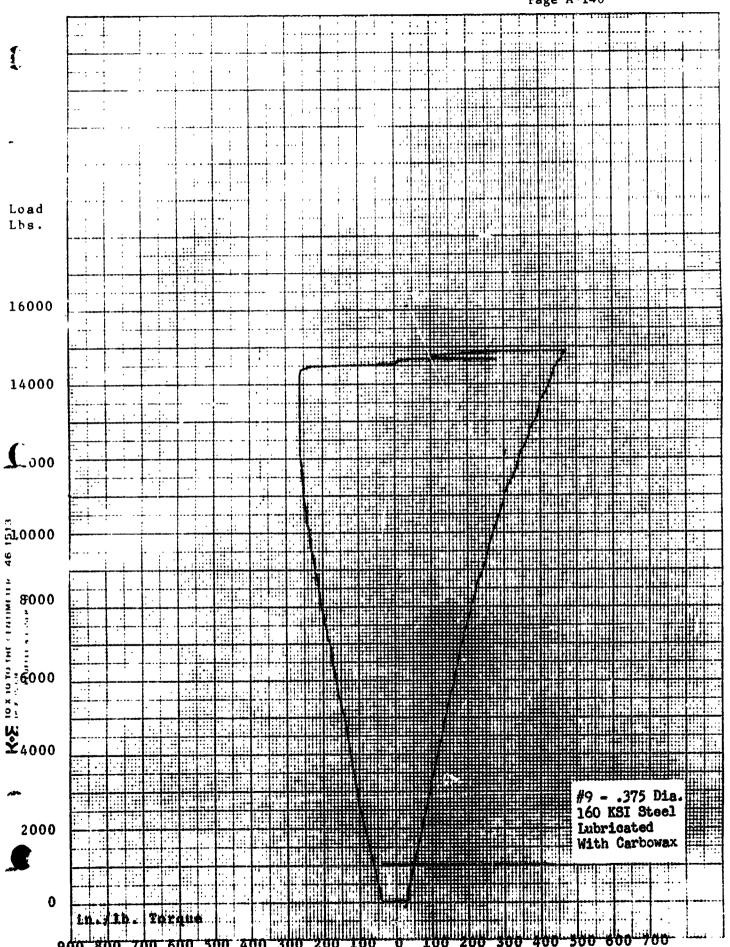


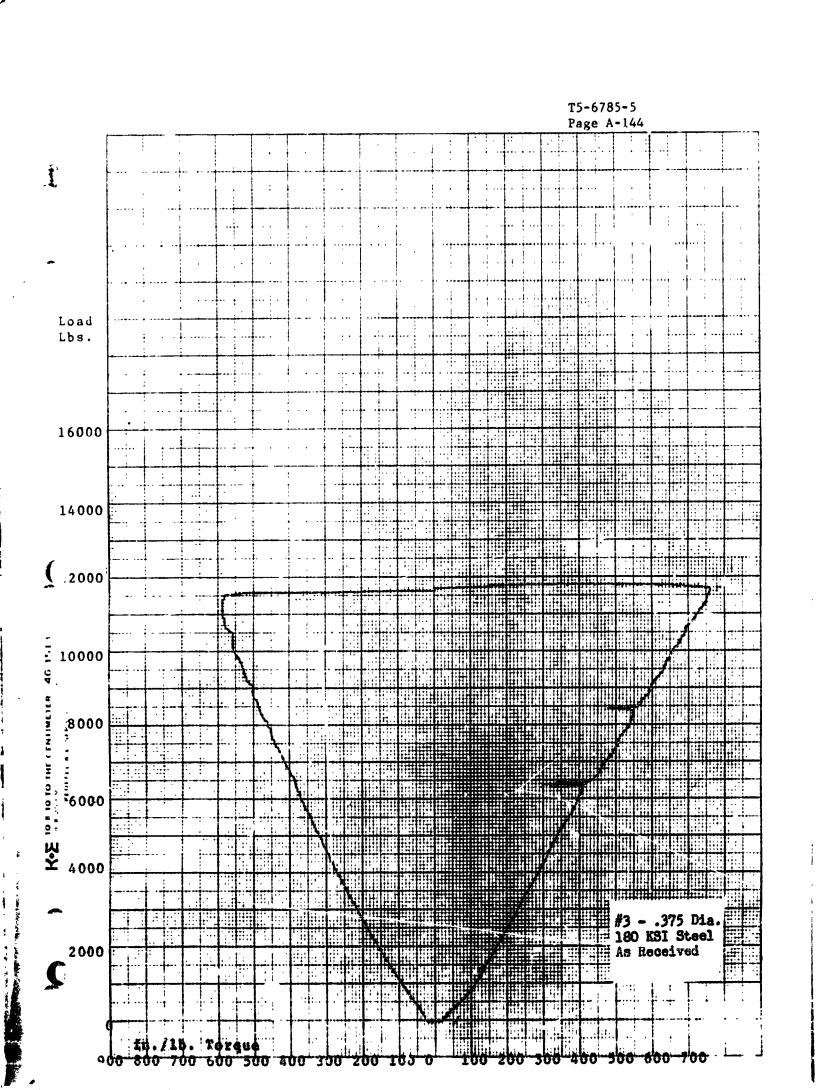


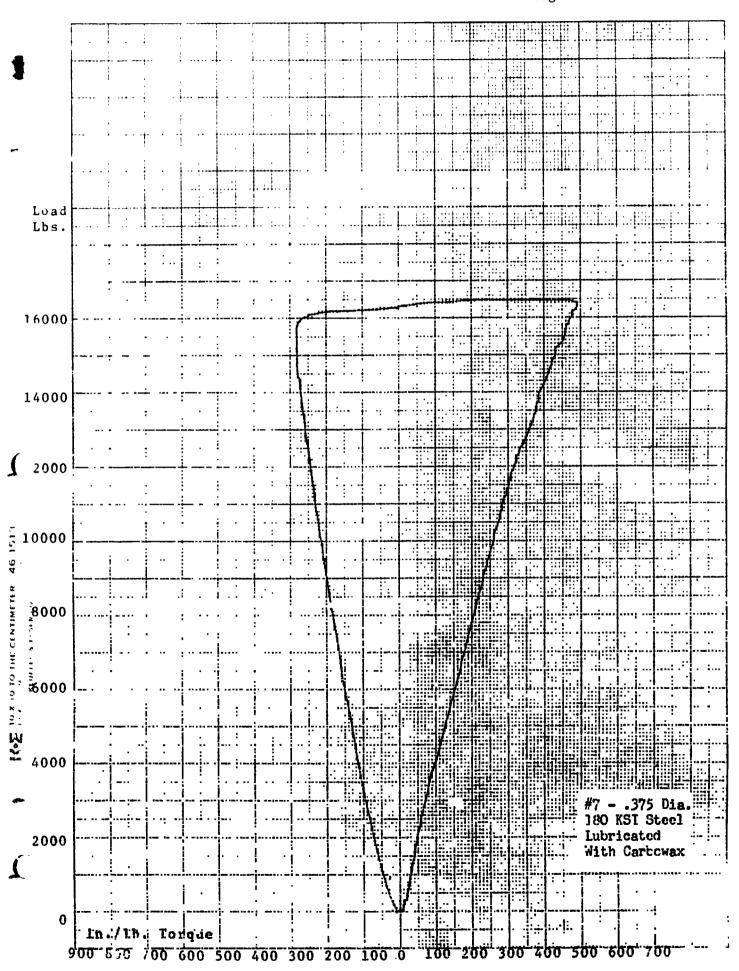
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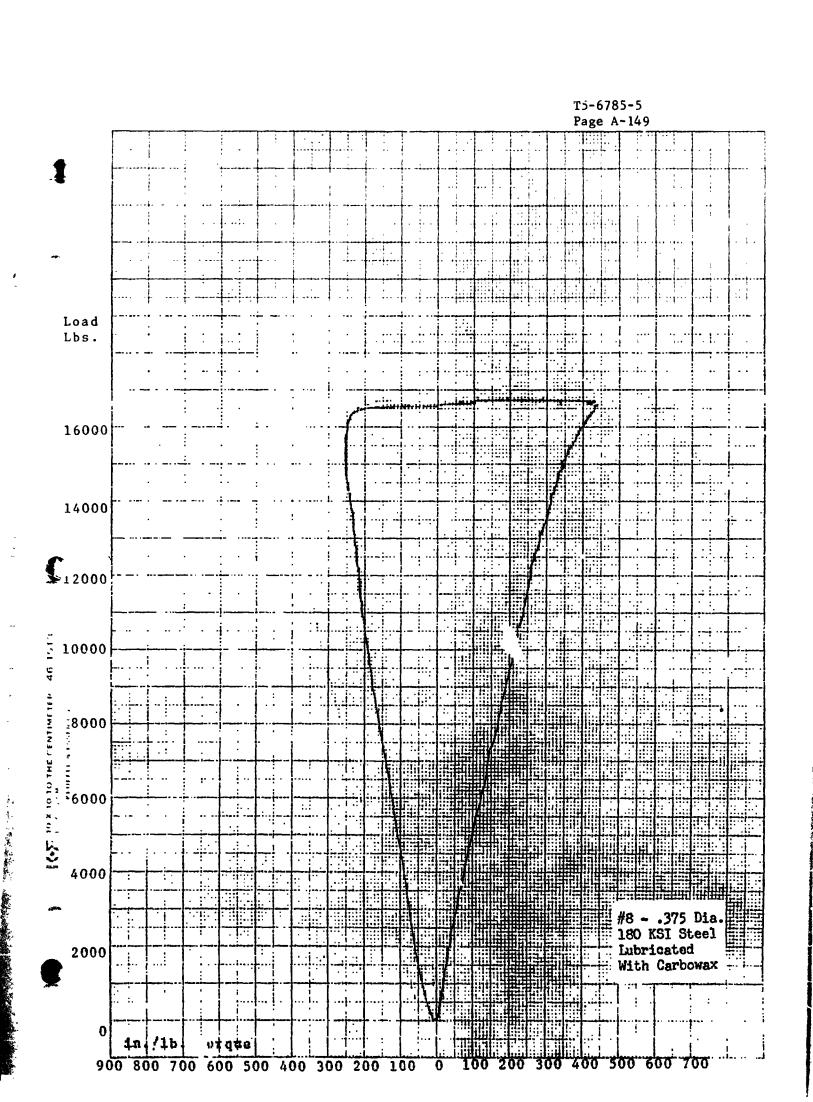
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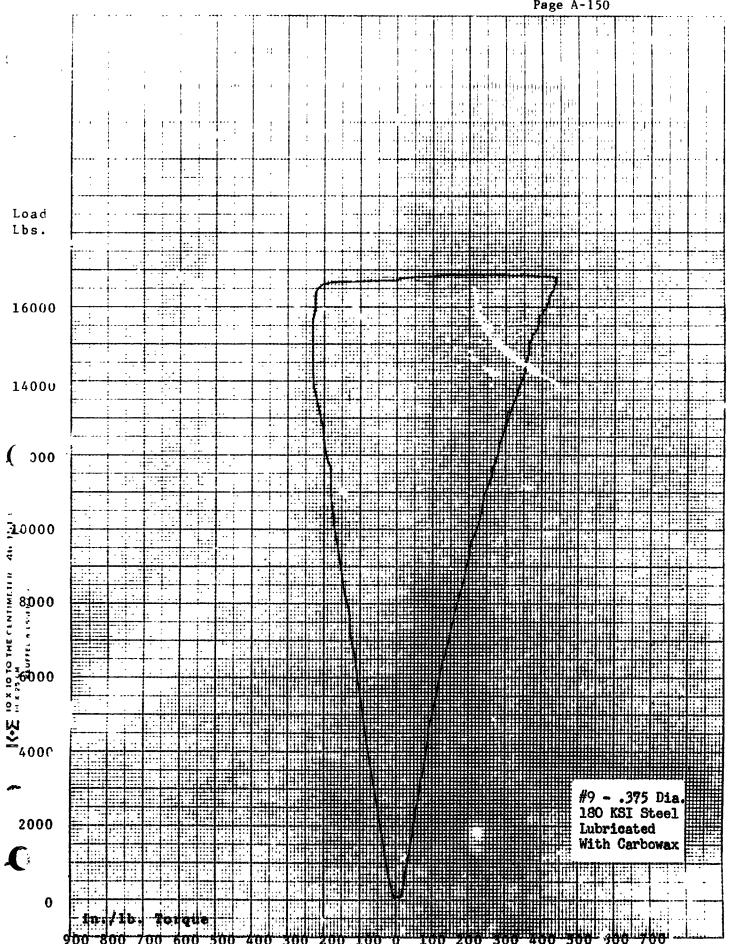


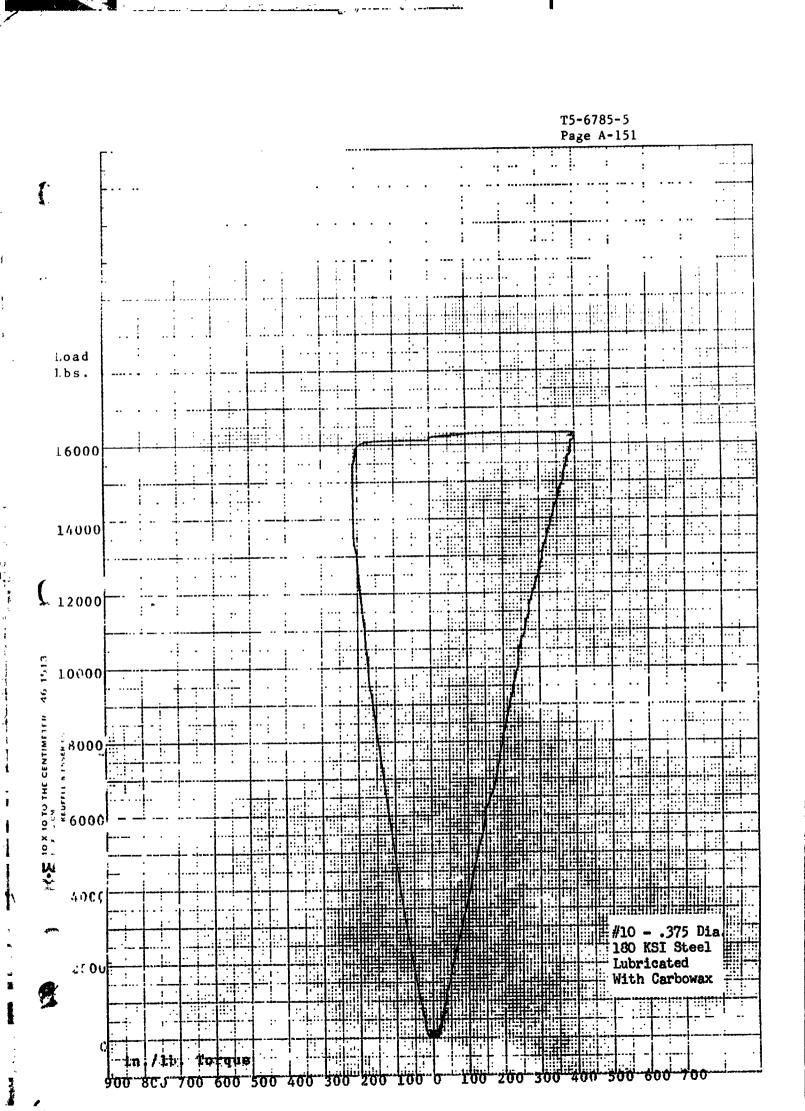






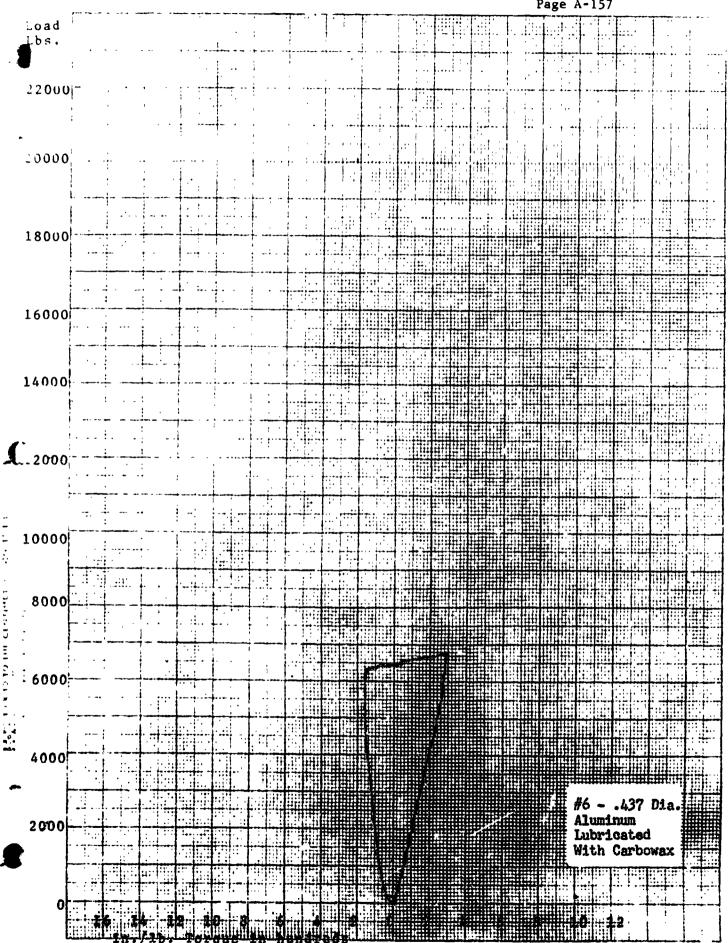






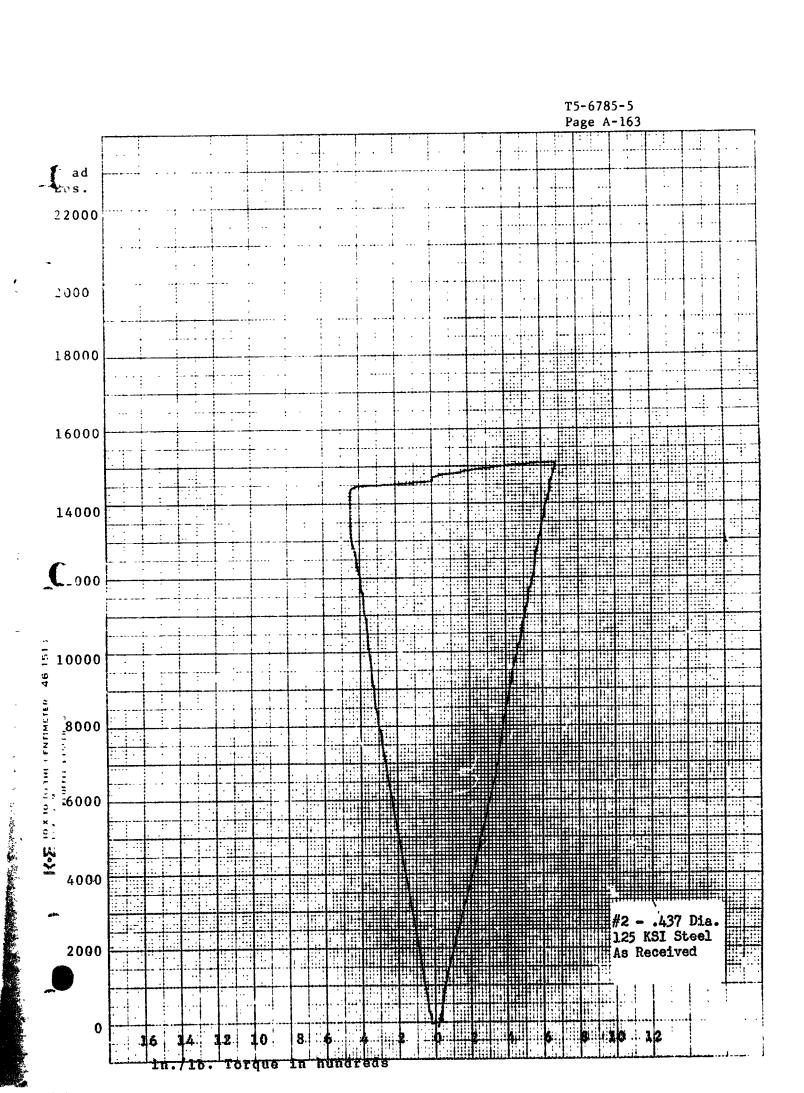
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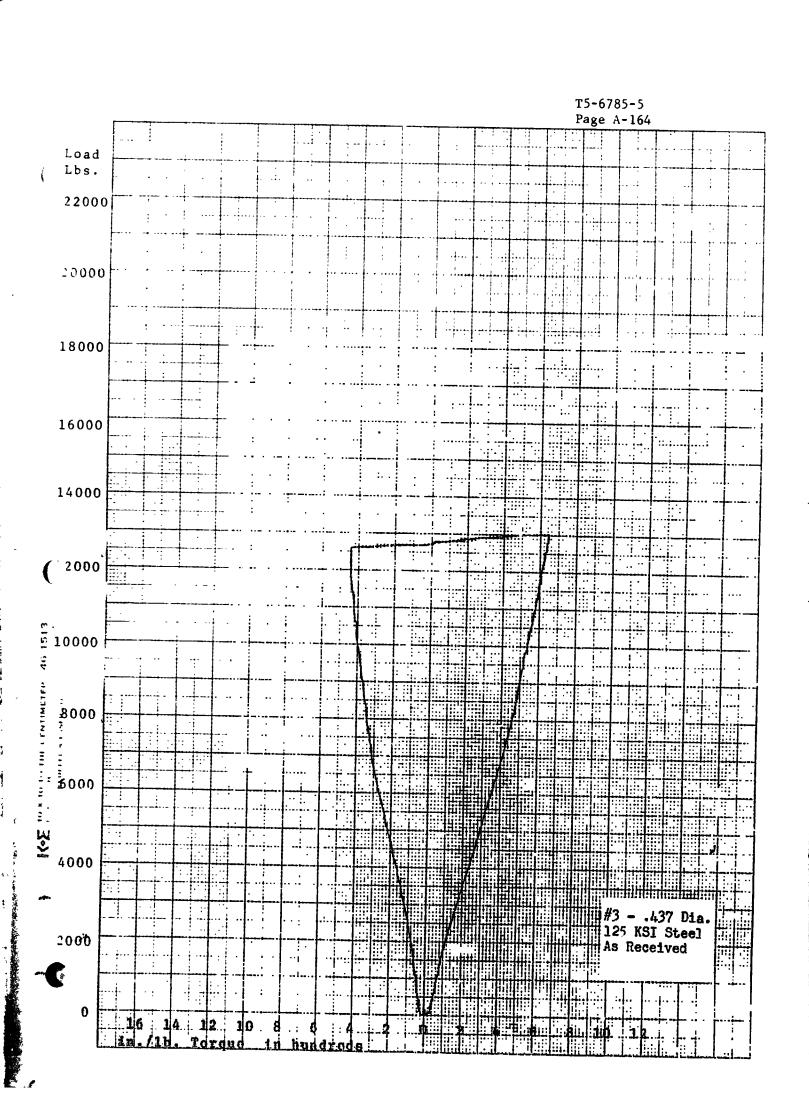
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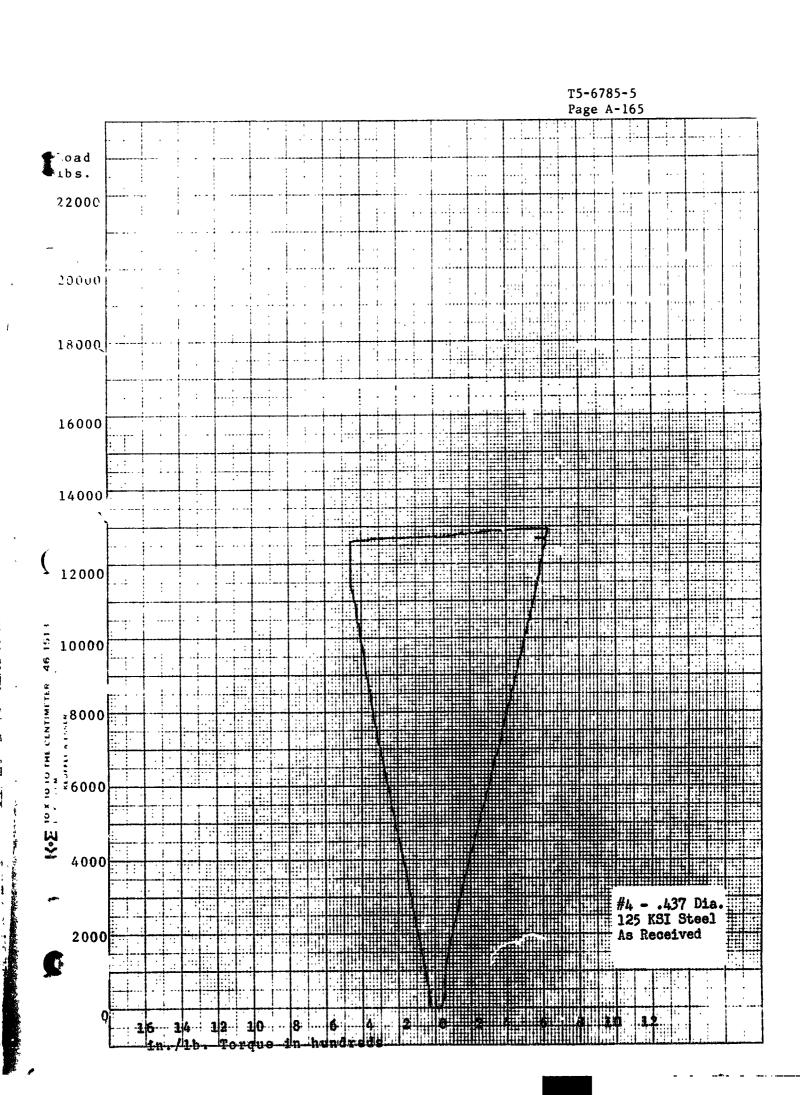


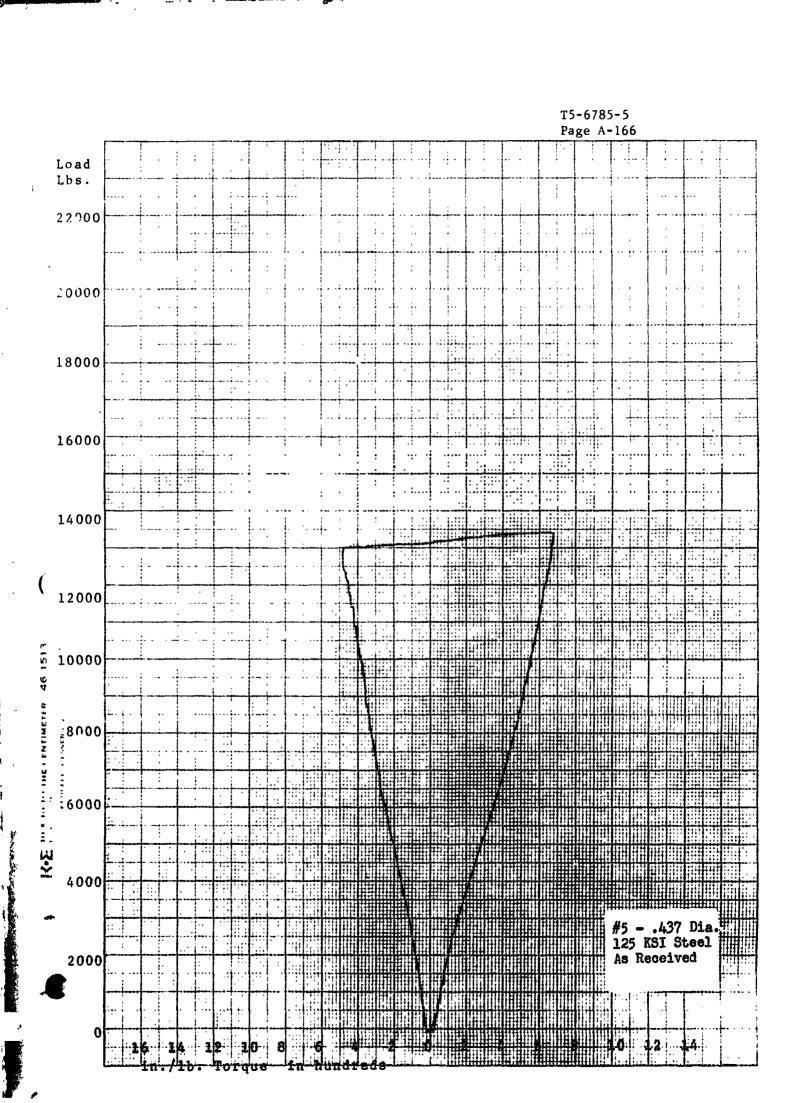
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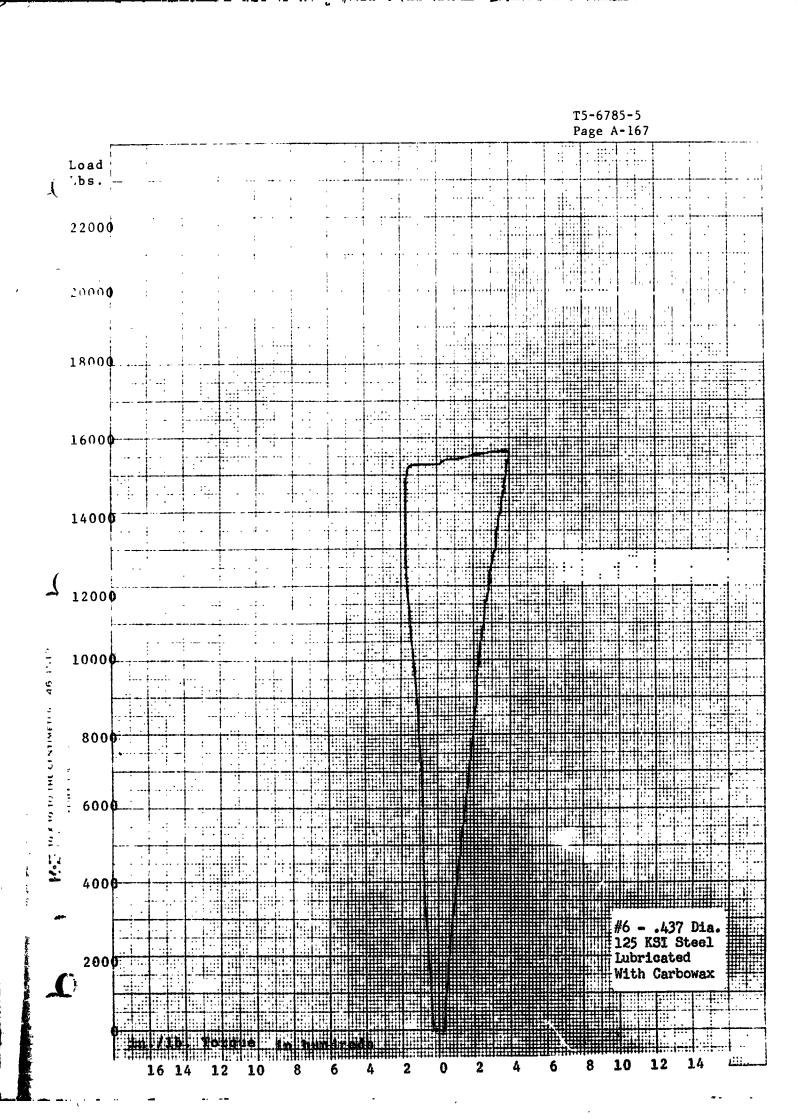
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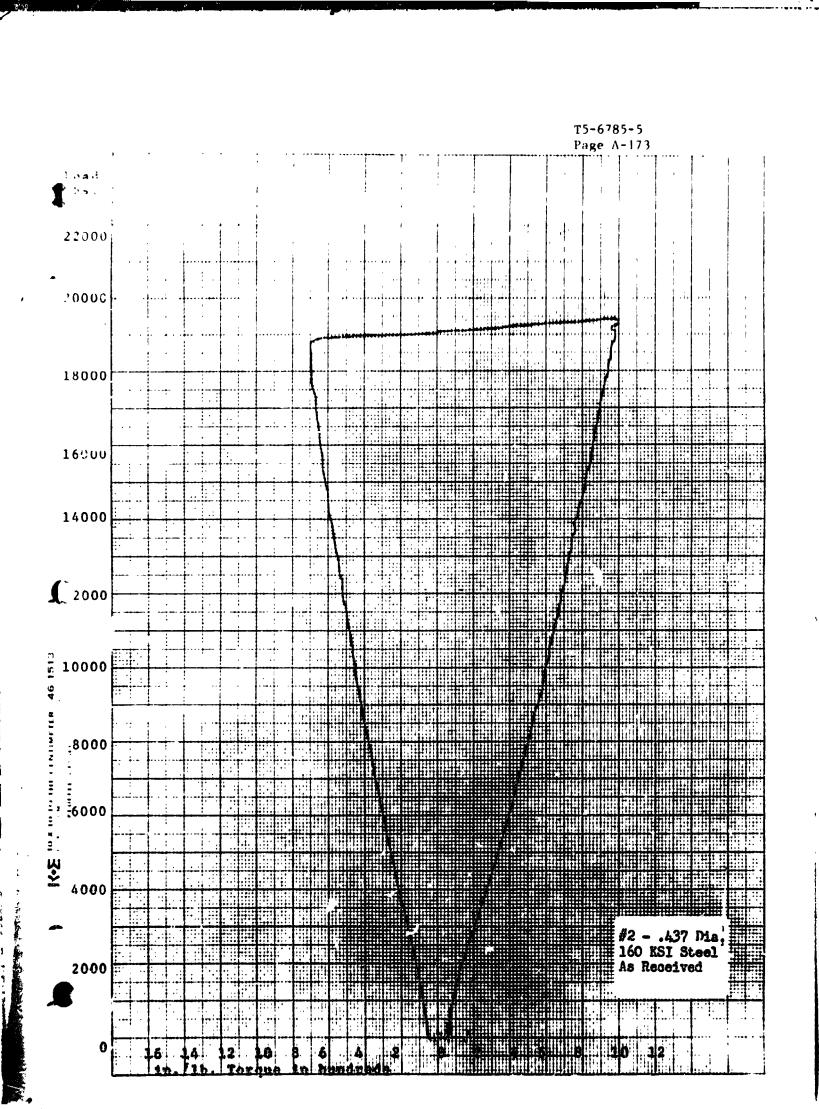


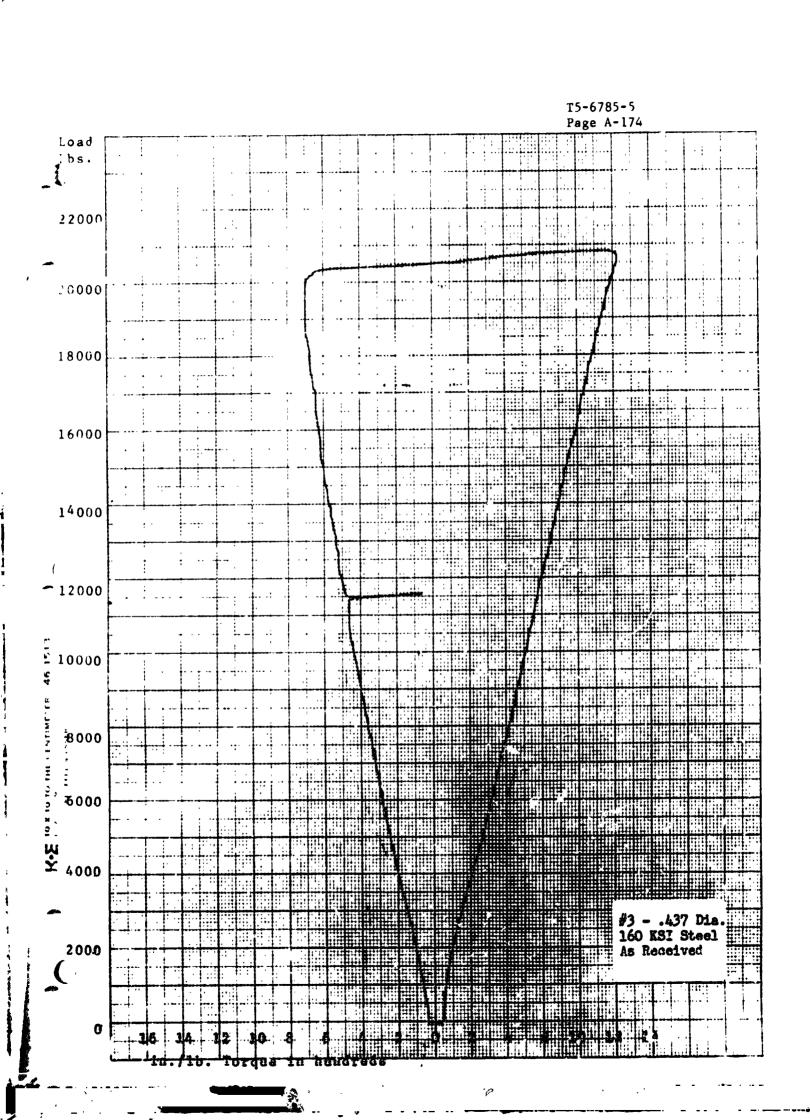




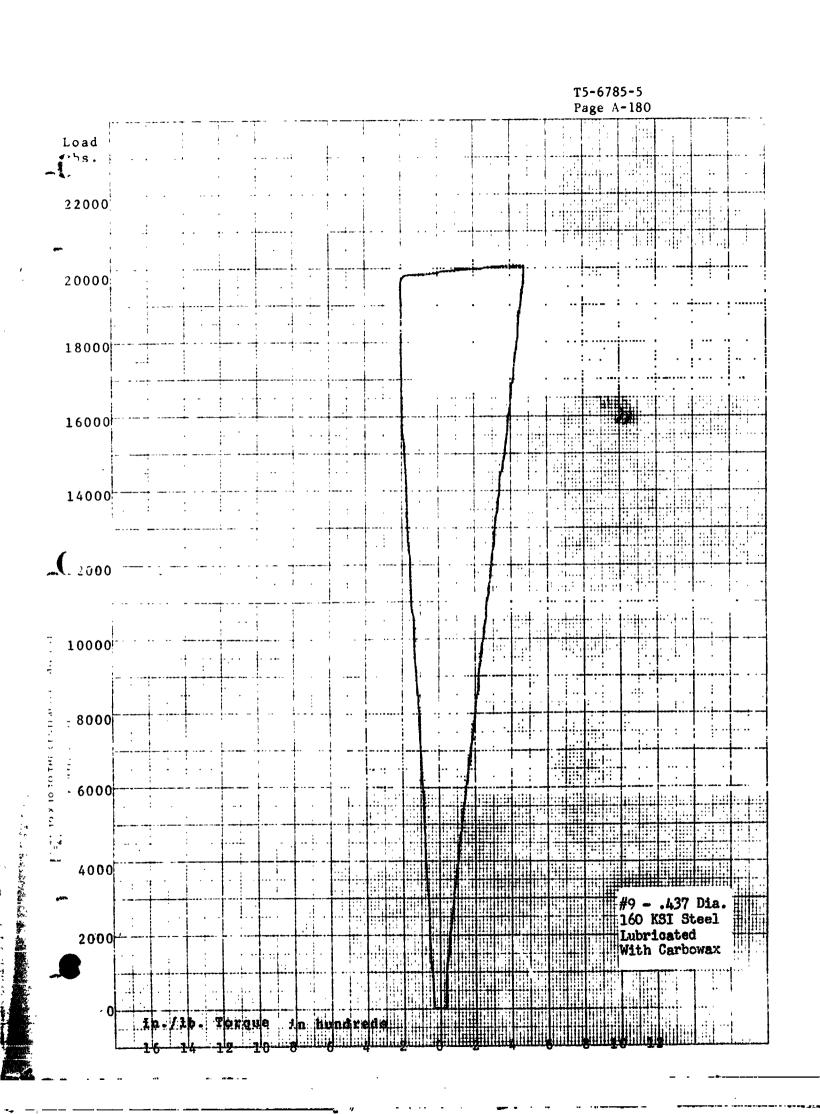


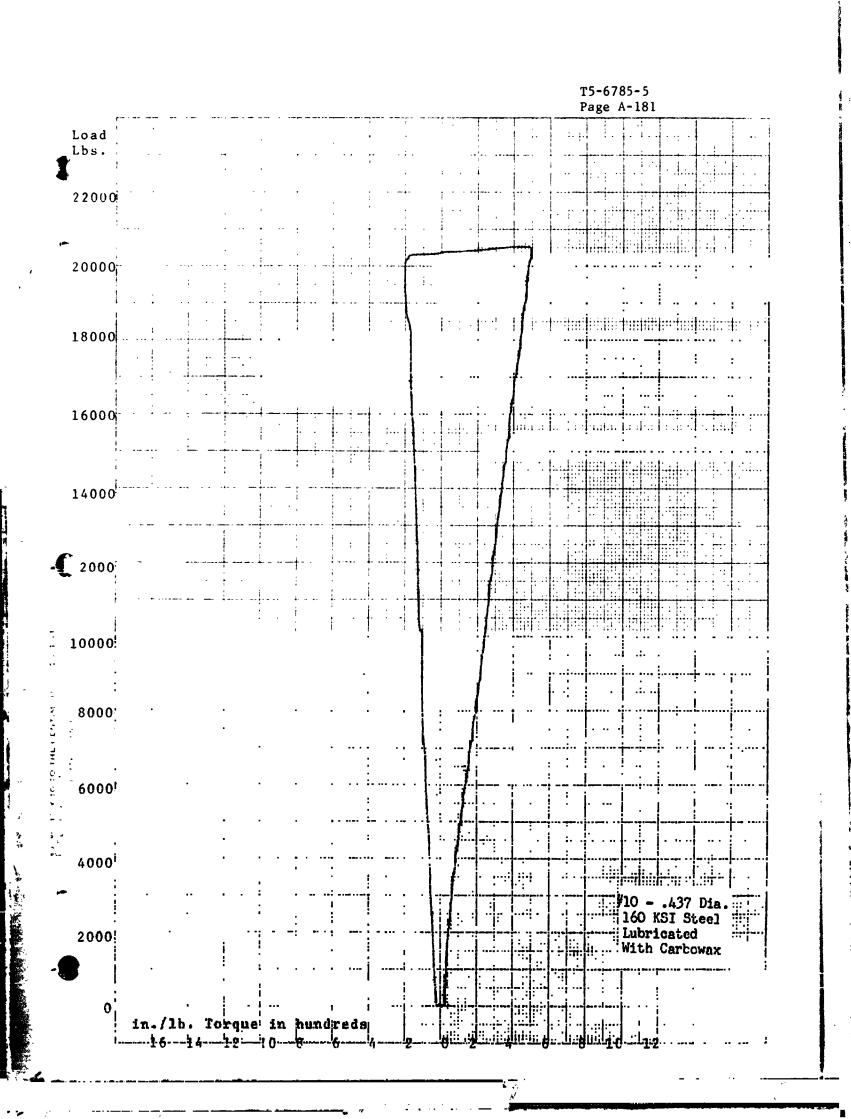


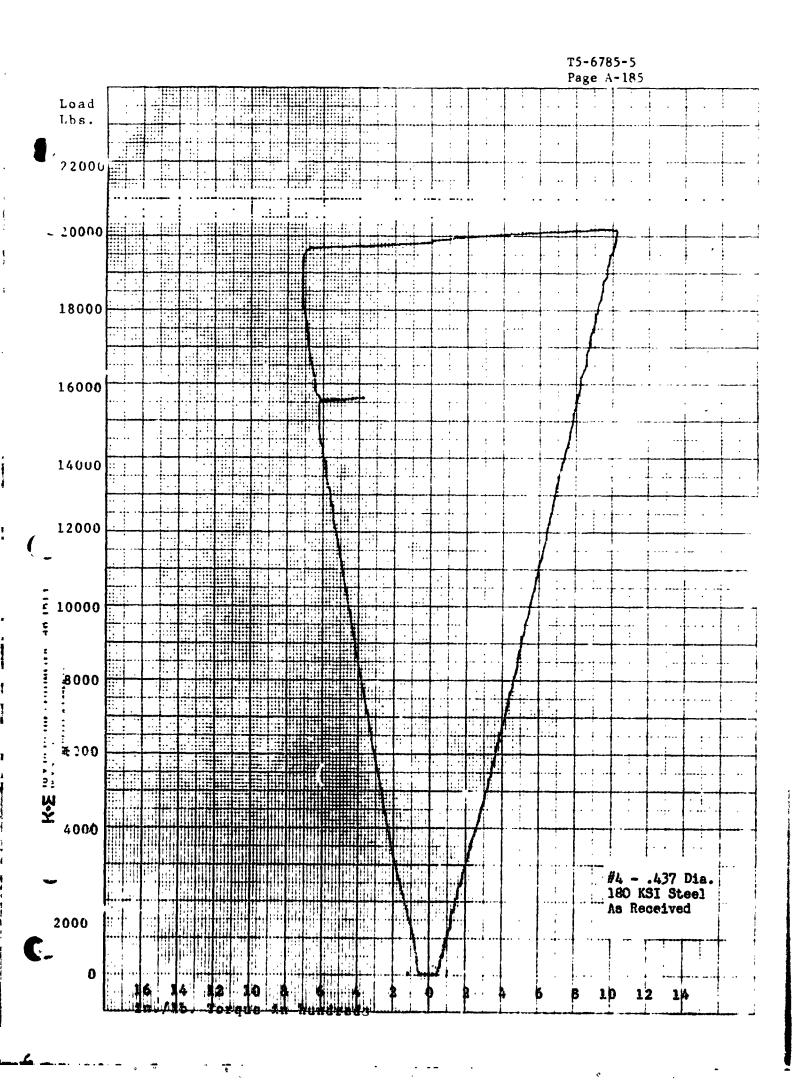


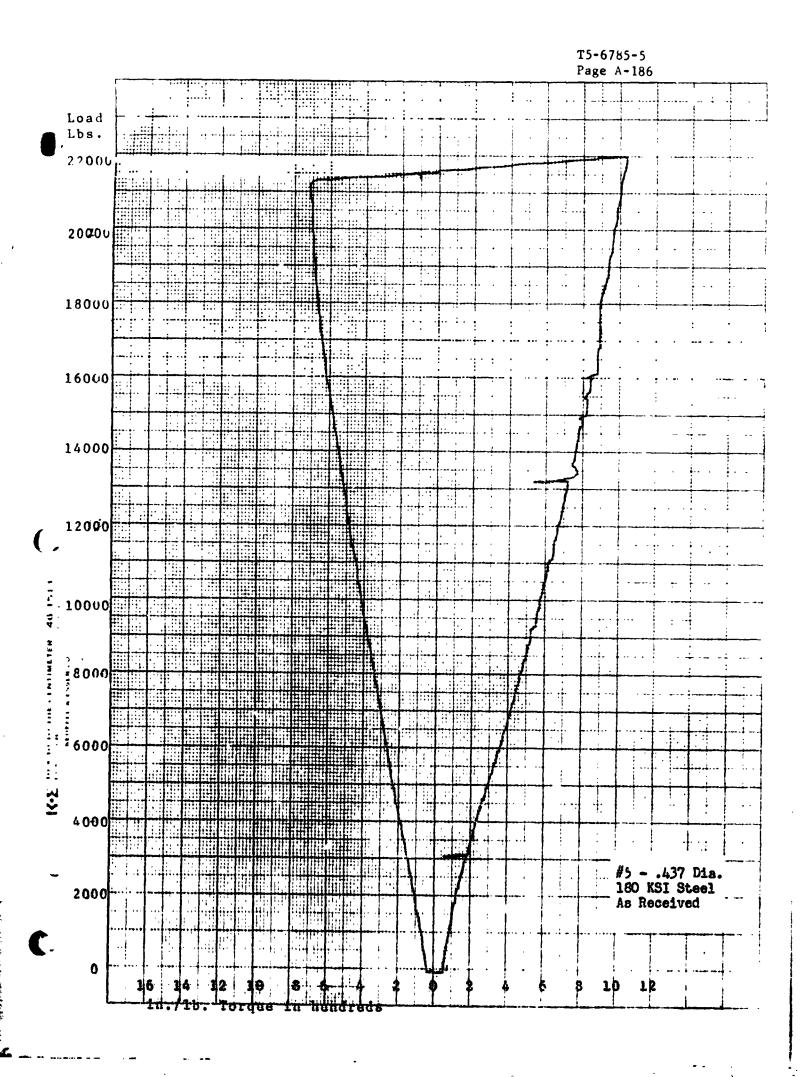


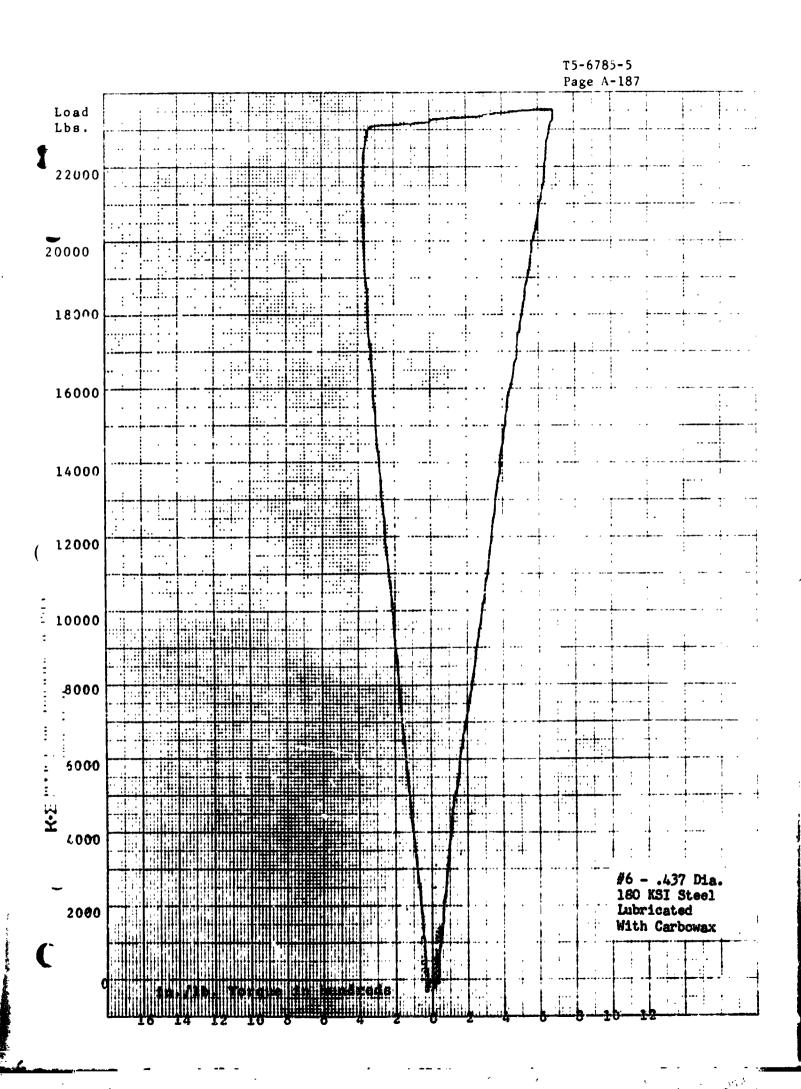
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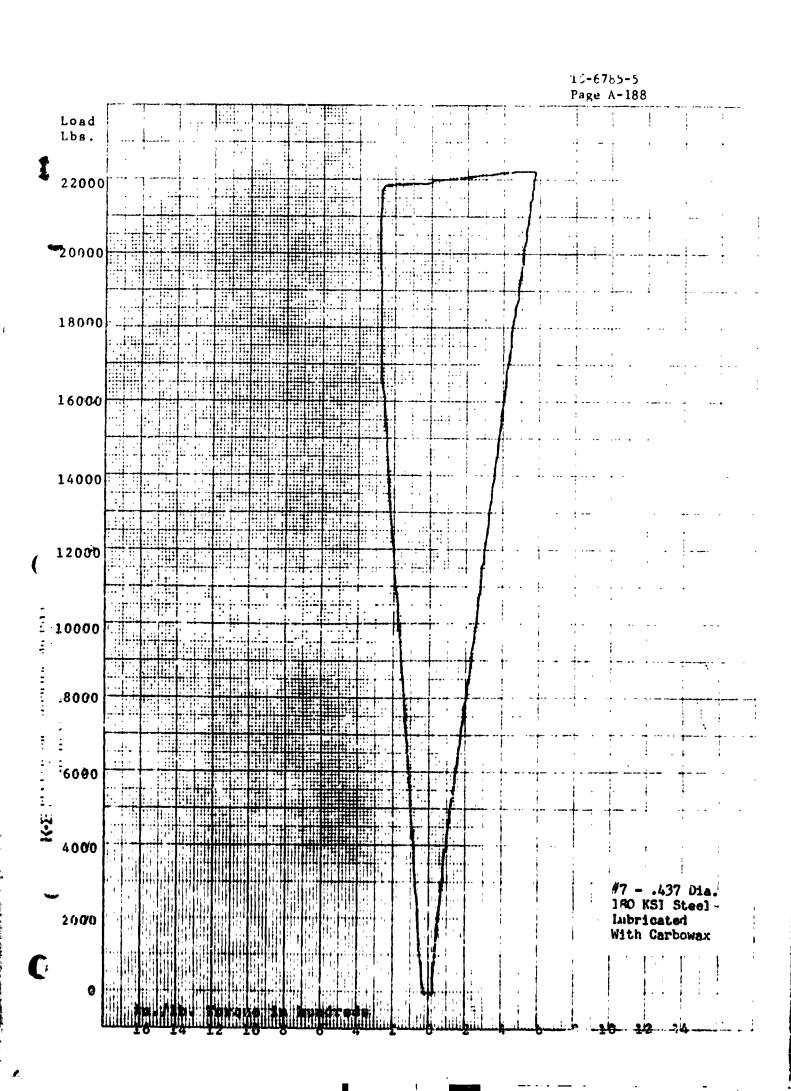


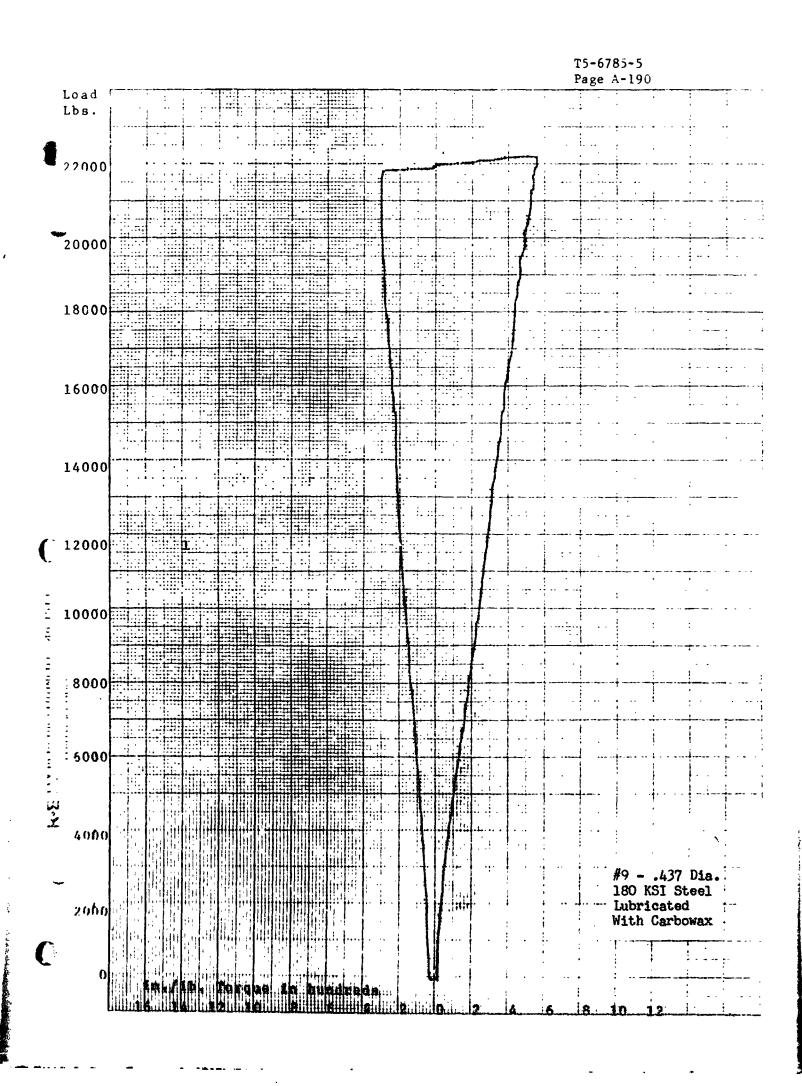


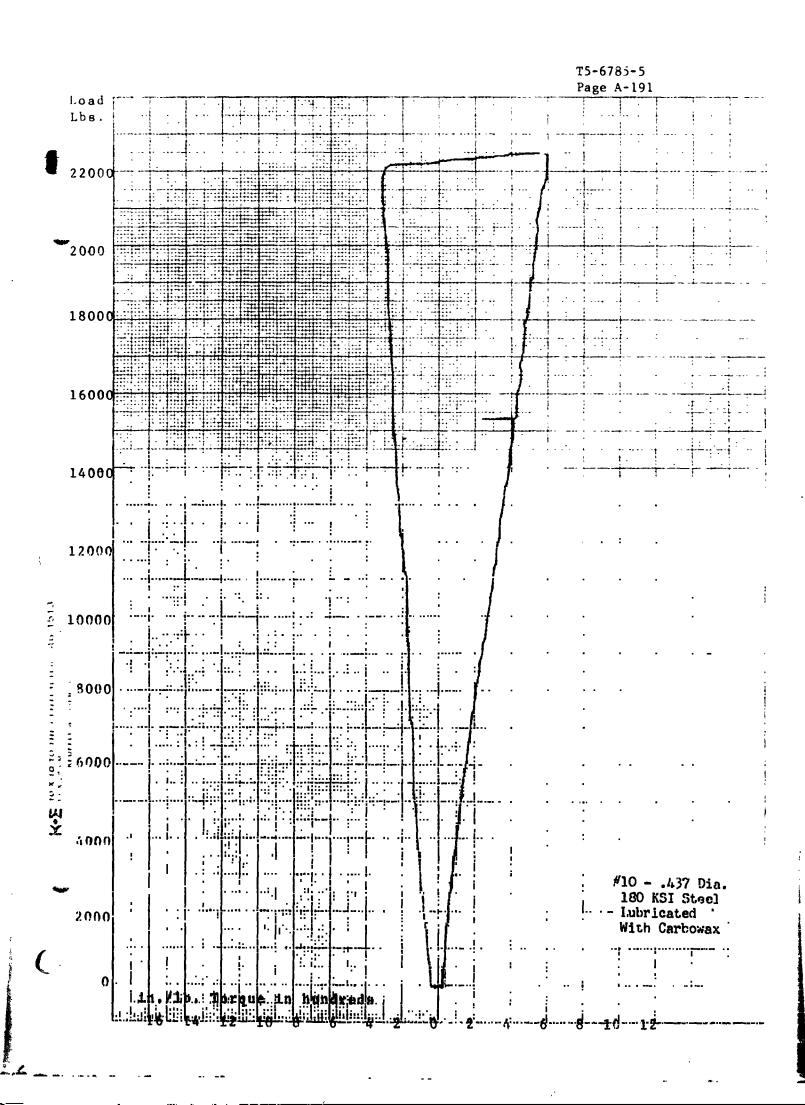












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